REMEDIAL INVESTIGATION/ FEASIBILITY STUDY (RI/FS) WORK PLAN

Falcon Refinery Superfund Site
Ingleside
San Patricio County, Texas
TXD 086 278 058

Prepared for

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LIST OF ACRONYMS

AOC	Area of Concern
ADSM	Alternative Development and Screen Technical Memorandum
API	American Petroleum Institute
ARAR	Applicable or Relevant and Appropriate Requirements
AST	Above-ground Storage Tank
ASTM	American Society for Testing Materials
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient Water Quality Criteria
bbl	Barrels
bgs	Below ground surface
BERA	Baseline Ecological Risk Assessment
BHHRA	Baseline Human Health Risk Assessment
BS&W	Basic Sediment and Waste
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
CBBF	Coastal Bend Bays Foundation
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CID	Criminal Investigation Division
CIP	Community Involvement Plan
COC	Chemical or Compound or Contaminant of Concern
COPC	Chemical or Compound or Contaminant of Potential Concern
COPEC	Chemical of Potential Ecological Concern
CRQL	Contract Required Quantitation Limits
CR	Cancer Risk
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
CTTM	Candidate Technologies Technical Memorandum
DQO	Data Quality Objectives
EC	Exposure Concentration
EDI	Estimated Daily Intake
ELCR	Excess Lifetime Cancer Risk
EPA	United States Environmental Protection Agency
EPC	Exposure Point Concentration
FDEP	Florida Department of Environmental Protection
FETAX	Frog Embryo Teratogenesis Assay-Xenopus
FI	Fraction ingested
FS	Feasibility Study
FSP	Field Sampling Plan
FRC	Falcon Refining Company
GCC	Gulf Conservation Corporation
HEAST	Health Effects Assessment Summary Tables
HI	Hazard Index
HQ	Hazard Quotient
HRS	Hazard Ranking System Documentation Record, Falcon Refinery
HSDB	Hazardous Substance Data Bank

HSP	Health and Safety Plan
IR	Ingestion Rate
IRIS	Integrated Risk Information System
LD_{50}	Median Lethal Dose
LOAEL	Lowest Observed Adverse Effects Level
LPST	Leaking Petroleum Storage Tank
MCL	Maximum Contaminant Level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MRL	Minimal Risk Level
NCAM	Nine Criteria Analysis Memorandum
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOAA	National Oceanic Atmospheric Administration
NOAEL	No Observable Adverse Effects Level
NORCO	National Oil Recovery Corporation
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
O&M	Operations and Maintenance
OMOE	Ontario Ministry of Environment
OMS	Odorless Mineral Spirits
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
OU	Operating Units
PAH	Polycyclic Aromatic Hydrocarbons
PC	Project Coordinator
PCB	Polychlorinated biphenyl
PCL	Protective Concentration Level
PF	Problem Formulation
PPE	Probable Point of Entry
ppm	parts per million
PPRTV	Peer Reviewed Toxicity Values
PRG	Preliminary Remedial Goal
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RA	Removal Action
RACA	Remedial Alternatives Comparative Analysis
RAGS	Risk Assessment Guidance for Superfund
RAIS	Risk Assessment Information System
RI/FS	Remedial Investigation / Feasibility Study
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
RME	Reasonable Maximum Exposure
RPM	Remedial Project Manager
RRC	Railroad Commission of Texas
RTECS	Registry of Toxic Effects of Chemical Substances
SAP	Sampling and Analysis Plan

SL	Soil Screening Level
SLERA	Screening-Level Ecological Risk Assessment
SOW	Scope of Work
STSC	Superfund Health Risk Technical Support Center
TA	Technical Advisor
TACB	Texas Air Control Board
TAG	Technical Assistance Grant
TCEQ	Texas Commission on Environmental Quality
TCLP	Toxicity Characteristic Leaching Procedure
TDWR	Texas Department of Water Resources
T&E	Threatened and Endangered
TIC	Tentatively Identified Compound
TL	Target Level
TNRCC	Texas Natural Resource Conservation Commission
TPH	Total Petroleum Hydrocarbons
TPDES	Texas Pollutant Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TRV	Toxicity Reference Value
TS	Treatability Study
TWC	Texas Water Commission
UCL	Upper Confidence Limit
µg/kg	micrograms per kilogram
µg/l	micrograms per liter
USGS	United States Geological Survey
VCP	Voluntary Cleanup Program

1.0 INTRODUCTION

This Remedial Investigation/Feasibility Study (RI/FS) Work Plan will be directed by the *Administrative Order on Consent for Remedial Investigation and Feasibility Study, CERCLA Docket No 06-05-04*, (Order) between the United States Environmental Protection Agency (EPA) and National Oil Recovery Corporation (NORCO).

The objectives of the RI/FS are: (a) to determine the nature and extent of contamination and any threat to the public health, welfare, or the environment caused by the release or threatened release of hazardous substances, pollutants, or contaminants at or from the Site, by conducting a Remedial Investigation; (b) to determine whether Remedial Action is necessary by conducting a Baseline Risk Assessment; and (c) to evaluate alternatives for Remedial Action, if any, to prevent, mitigate or otherwise respond to or remedy any releases or threatened release of hazardous substances, pollutants, or contaminants at or from the Site or facility, by conducting a Feasibility Study.

The three governing documents provided for this phase of the RI/FS are the:

- RI/FS Work Plan;
- RI/FS Sampling and Analysis Plan; and
- RI/FS Health and Safety Plan.

These documents should be considered "living documents" and if it becomes necessary all three will be modified to address any change in conditions at the site.

The RI/FS Work Plan (Plan) provides a description of planned field activities that will be conducted during this initial characterization of the site, in accordance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980 (CERCLA, 42 U.S.C. §9601, *et seq.*) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

This Plan has been developed in accordance with the EPA's "Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA" (RI/FS guidance) and the Order. Specifically, the Plan will present a statement of the problem(s) and potential problem(s) posed by the Site and the objectives of the RI/FS.

The RI/FS Sampling and Analysis Plan (SAP) consists of the Field Sampling Plan (FSP) and the Quality Assurance Project Plan (QAPP).

Included in the FSP are detailed sampling and data gathering methods that will be used to define the nature and extent of contamination and to develop the human and ecological risk assessments.

The QAPP describes the project objectives and organization, functional activities, and quality assurance and quality control (QA/QC) protocols. All sampling and laboratory analytical methods and procedures to be performed will conform to EPA direction, approval and guidance regarding sampling, quality assurance/quality control, data validation and chain of custody procedures. Analytical laboratories used for this project will be accredited under the National Environmental Laboratory Accreditation Program (NELAP) and will comply with appropriate EPA guidance.

The RI/FS Health and Safety Plan (HSP) has been prepared in accordance with Occupational Safety and Health Administration (OSHA) regulations and protocols. The HSP is designed to be used during this and future phases of work at the site as a guide to the safe handling of chemicals, selection of sampling equipment, selection of proper personal protection equipment, and emergency response procedures. The HSP is intended to provide guidance to both site workers and any potential visitors.

References in this report are either cited fully herein or were taken from the Hazard Ranking System Documentation Record, Falcon Refinery, which was prepared by the Texas Natural Resource Conservation Commission (TNRCC) for the EPA.

NORCO acknowledges that the EPA uses the term “Site”, which is not defined in CERCLA, in referring to a “release” or “facility” on the National Priorities List (NPL). However, for this Plan the term Site (uppercase “S”) or on-site will be used to describe property owned by NORCO including the North Site, South Site and the Barge Dock Facility. When referring to the overall area the term site (lowercase “s”) or off-site will be used. Also, “facility” will be used to describe property and equipment owned by NORCO or some other specified adjacent entity. NORCO recognizes that under CERCLA the terms facility and release are interchangeable.

2.0 2.0 SITE BACKGROUND AND SETTING

The Falcon Refinery (a.k.a. NORCO) Site consists of a refinery that operated intermittently and is currently inactive. When in operation the refinery had a capacity of 40,000 barrels (bbl) per day and the primary products consisted of naphtha, jet fuel, kerosene, diesel, and fuel oil.

The Site occupies approximately 104 acres in San Patricio County, Texas, and is located 1.7 miles southeast of State Highway 361 on FM 2725 at the north and south corners of FM 2725 and Bishop Road (Figure 1, Area Map). Other portions of the site include piping leading from the Site (North and South) to dock facilities at Redfish Bay, where crude oil and hydrocarbons were historically and are currently transferred between barges and storage tanks, where vinyl acetate was historically transferred and may be stored, and any other area where contamination attributed to the Site is now located.

2.1 Site History

The Site (Figure 2, Site Map and Figure 2a Pipeline Map) has been owned, leased and/or operated under several different companies. The Oil and Gas Company of Texas, Inc. originally owned the Site. A deed search revealed that the facility was leased to UNI Refining, Inc. from the UNI International Corporation and the UNI Pipeline, Inc. for seven years, 1979-1986. UNI Refining Co. obtained an air permit in 1979 and commenced construction of the facility in April 1980. In March 1981, UNI Oil, Inc., the parent corporation of UNI Refining Company and UNI Pipeline Company, was sold to new owners operating under the name of Texas Independent Oil Corporation. In late 1983 to early 1984, the refinery was sold and began to be operated under the name Mid Gulf Energy, Inc.

The Falcon Refining Company (FRC) purchased the Site from Texas Independent Refining facility in November 1985. In 1986, production at the refinery once again ceased, FRC declared bankruptcy and the facility came under the ownership of American Energy Leasing, Inc. In May 1990, Impexco of Texas, Inc. acquired the Site from American Energy Leasing, Inc.

NORCO gained title to the refinery in December 1990 from Impexco of Texas, Inc. In June 1991, NORCO acquired the dock facility from the Sun Operating Limited Partnership. In the mid-1990s, MJP Resources, Inc. began leasing/operating the tanks on the northwest corner of the FM 2725 and Bishop Road and at the dock facility. In 1998, Pi Energy Corporation acquired 2.5 acres of the dock facility from NORCO.

Currently, Superior Crude Gathering Inc. (Superior) is leasing several above-ground storage tanks (ASTs) at the refinery portion of the Site and the barge docking facility, for crude oil storage and transportation.

2.2 Site Characterization

The site is located near the city of Ingleside, in the San Antonio-Nueces Coastal Basin adjacent to Redfish Bay, which connects Corpus Christi Bay to the Gulf of Mexico. Surface water drainage from the Site enters the wetlands along the southeastern section of the abandoned refinery. The wetlands then connect to the Intracoastal Waterway and Redfish Bay. The Site is bordered by wetlands to the northeast and southeast, residential areas to the north and northwest, Plains Marketing (crude oil storage) to the north, and several construction companies and a waste oil recycler to the west.

2.2.1 Site Physical Characteristics

The Falcon Refinery occupied two separate parcels of land that were connected by pipelines. The refinery property is located south of the intersection of FM 2725 and Bishop Road and the storage and former truck racks are located north of the same intersection.

When operational the storage and truck rack property (North Site) had nine ASTs that ranged in size from 1,000 bbls (Tank 3) to 20,000 bbls (Tanks 8 and 9), three truck loading racks, associated piping and a transfer pump (Figure 3). At the time of the submission of this work plan, only Tank 2 and Tank 7 from the operational facility are still present on-site. Three small tanks have been placed at the North Site near the former truck racks since the facility was operational. The owner and contents of the nearly empty tanks are unknown.

There is also a half buried concrete tank on the North Site that does not appear on the Site plans. It appears that used motor oil was poured around this tank.

The main portion of the refinery (South Site) was located south of the intersection of FM 2725 and Bishop Road (Figure 4).

When operational the crude oil topping plant produced light naphtha, heavy naphtha, kerosene and diesel. Operational equipment at the Site includes a cooling tower, crude exchanger, steam generator, vacuum cooler, blending equipment, heat exchangers, charge pumps, residue pumps, slop pumps, condensate pumps, water circulating pumps, sulfuric acid injection pumps, cooling water pumps, a vacuum column, condensate separator, flame arrestor, chlorinator, steam exhaust, chemical feed system and an HVAC pressurizing system. Storage consisted predominantly of Tanks 10 through 31, which ranged in size from 5,000 bbls (Tanks 17-24) to 200,000 bbls (Tank 30). Two additional tanks N1 and N2 (Tanks 32 and 33 respectively, of the main processing area of the refinery [Figure 4]), were also used to store product, including CERCLA hazardous substances. In addition there is a large fire water tank near the main entrance to the facility.

Storm water and process water were sent to storage tanks that had American Petroleum Institute (API) separators that removed any residual oil and sent the oil to a slop tank. The water was treated by a dissolved air flotation chamber and then flowed into the aeration pond. Historically, sludge was then removed in the clarifier and it is believed that any effluent from the refinery's wastewater treatment system may have been discharged directly into the unpermitted wetland area immediately adjacent to the Site because the discharge pipeline may have never been constructed to the outfall discharge point.

2.2.1.1 Surface Features

The Site elevation is near sea level with a maximum of ten feet above sea level. The adjacent wetlands, geology, soil, groundwater, meteorology and human population are described in the following sections.

2.2.1.2 Geology

Surface deposits consist of Quaternary Alluvium, which is comprised of clay, silt and sand of varying grain size. Beneath the alluvium is the Pleistocene Aged Beaumont Clay, which is comprised of clay that is interbedded with medium to fine sand. Both formations typically yield small to moderate quantities of fresh to moderately saline water.

Texas Water Development Board (TWDB) Report 73, Groundwater Resources of Nueces and San Patricio Counties and Bureau of Economic Geology Maps were reviewed for descriptions of the shallow geology. Results of the reviews indicated that the character of the stratigraphy is heterogeneous and the correlation of individual beds is difficult even over short distances.

Boring logs from the adjacent Plains facility (Appendix A) indicate that the shallow geology at the site is predominantly sand to a depth of 12 feet below ground surface (bgs). Information on water well completion logs (Appendix B) in the area was too general to use in the interpretation of the geology.

Detailed cross-sections will be constructed of the shallow geology of the site after the drilling program of the RI.

2.2.1.3 Soil and the Vadose Zone

Fourteen monitor well borings (Appendix A) were reviewed from the Plains Marketing facility that adjoins the North Site to the northeast, north and northwest. The descriptions indicate that the shallow stratigraphy is predominantly silty sand with color variations including shades of gray and brown and zones of black organic material. Some of the borings encountered basal clay at depths ranging from 10 to 12 feet bgs.

During drilling for the borings groundwater was encountered at depths ranging from three to eight feet bgs.

2.2.1.4 Surface Water Hydrology

The Site is bordered by wetlands that are described as palustrine emergent areas and estuarine intertidal emergent areas that are regularly flooded (Ref.53, p.1) to the south, east and northeast. The wetlands, which drain from the Site to the northeast, eventually connect to Redfish Bay, Corpus Christi Bay, Aransas Bay and the Gulf of Mexico.

Located in the San Antonio-Nueces Coastal Basin, the Site lies approximately 5 feet above sea level and drains into the adjacent wetlands. The topography of the Site is gently sloping to the southeast as revealed by the Port Ingleside, Tex., United States Geological Survey (USGS) topographic map. Surface water drainage from the Site enters the wetlands along the southeastern section of the refinery.

A culvert connects the palustrine/estuarine wetlands to estuarine wetlands. An aerial photograph (Figure 5) shows the connection between the wetlands to the Intracoastal Waterway and Redfish Bay.

Hazardous substances from the Site possibly entered surface water by overland flow from the Site through sandy berms and the cracked foundation of the lined surface impoundment and by surface water runoff during rain events. Hazardous substances also possibly entered the

Intracoastal Waterway from the current and historical docking facility by overland flow and surface water runoff during rain events and through the culvert located north of the historical barge dock facility.

There are several reports that the Falcon Refinery had a permitted National Pollutant Discharge Elimination System (NPDES) discharge point at the southern end of Hwy 2725. An application for Permit number 02142 was last submitted to the EPA on March 10, 1993 by Monitor Environmental on behalf of NORCO. The permitted discharge point was in Corpus Christi Bay approximately four miles from the refinery.

Mr. Doug Standifer, a former consultant for the Falcon Refinery, indicated that he had authorized the submittal of a permit for an NPDES discharge permit. However, there are no records to indicate that wastewater effluent discharges occurred under the permit and that the permit was ever used. Additionally, there are no records to indicate that the discharge pipeline was ever connected to the outfall point at Corpus Christi Bay. It is believed that the wastewater treatment effluent may have been directly discharged into the unpermitted wetland area immediately adjacent to the Site.

2.2.1.5 Meteorology

Average annual rainfall at the site approximately is 35.0 inches per year and the 2-year maximum 24-hour rainfall is 4.5 inches. Based on the Federal Emergency Management Agency Flood Insurance Rate Map for San Patricio County, Texas, Panel 531 of 533, Map Revised: March 18, 1985, the Site is within a 100-year floodplain.

2.2.1.6 Human Population and Land Use

The Site is located approximately 2.5 miles from the city of Ingleside, which has a population of approximately 9,400 people. Land use adjacent to the Site is comprised of predominantly industrial facilities (Figure 6). However, there are residences immediately west (at the intersection of FM 2725 and Bishop Road) and north of the refinery Site along Thayer Road. Additional information associated with land use is provided in Sections 5.4 and 5.5.8.

A one-mile radius water well search was performed and the report is provided in Appendix B. Information obtained in the water well search, which included all wells registered with the Texas Department of Water Resources, indicated that there are two registered water wells on Thayer Road, which is adjacent to the refinery. In addition to the search for registered wells a door-to-door search (Figure 7) was conducted and two water wells were found on Bishop Road. State of Texas Water Well Reports indicate that the two registered water wells on Thayer Road are screened in sand at a depth of 40 to 45 feet below land surface.

The depth to groundwater beneath the Site has been estimated at 3 to 8 feet bgs. No permanent groundwater monitor wells have been installed at the Site. However, monitor wells at the adjacent Plains site encountered groundwater in that range. Provided in Appendix A are boring logs from Plains, which indicated that the shallow geology is predominantly sand.

In addition to the presence of hydrocarbons noted near the above-ground tanks at the Site, other potential sources of groundwater contamination include on-site and off-site pipelines, above-ground storage tanks, former drum storage areas, oil pits, and metal refuse areas.
The RI will reveal if the basal clay is consistent across the Site.

Adjacent businesses include (Figure 6):

- Oceaneering Solus Schall
- Southern Steel & Supply
- MMR Constructors Inc.
- Backwood's Grill
- State Service Co. Inc. (SSCI)
- Raymond Dugat Co., L.C. (Ingleside Properties aka Dugat Docks)
- Offshore Specialty Fabricators, Inc. (Gulf Conservation Corporation (GCC))
- TJs Machine Shop
- Gulf Marine Fabricators (Aker Gulf Marine – Aransas Pass Yard)
- Fincantieri Marine Systems
- Moose Lodge 2063
- Coastal Tech Fiberglass
- Playtime Amusements
- AG Produce
- Southland Fab & Offshore Inc.
- Surface Technologies Corporation
- Boss Exploration & Prod.
- New Park Environmental Services
- Live Oak Materials Inc.
- Garrett Construction Co.
- Lawn & Garden Shop
- Dynamic Industries, Inc.
- Plains Marketing LP
- Alamo Concrete Products LTD
- Perry Construction Co. Inc.
- ACI Concrete Construction
- ACI Mini Storage
- Baker Manufacturing Corporation
- Backwoods
- IBC Petroleum/ Pi Energy

Provided in Appendix C are Annual Waste Summary forms for a few of the adjacent facilities. The comprehensive file that contains the waste summaries and regulatory inspections is comprised of thousands of pages. When the RI data are obtained the COPC will be evaluated and compared to the listed facilities.

2.2.1.7 Endangered and Threatened Species

The area in and around the refinery and the adjacent wetlands is a known habitat for Federal and Stated designated endangered or threatened species (Ref. 78, p. 1). An inquiry through the Texas Parks and Wildlife Department (TPWD) Biological and Conservation Data System and a site visit from Mr. Beau Hardegree of the TPWD Lower Coast Conservation Assessment Program indicated the following endangered and threatened species in the vicinity of the wetland areas adjacent to the site. Federal Listed Endangered and State Listed Endangered Species, Brown Pelican (*Pelecanus Occidentalis*); State Listed Threatened Species, Reddish Egret (*Egretta Rufescens*). In the Redfish Bay environment: Federal Listed Endangered Species, Brown Pelican (P*elecanus Occidentalis*) and Kemp's Ridley sea turtle (*Lepidochelys Kempii*); Federal Listed Threatened Species, Green Sea Turtle (*Chelonia mydas*); State Listed Endangered Species, Brown Pelican (*Pelecanus Occidentalis*); State Listed Threatened Species, Reddish Egret (*Egretta Rufescens*) (Ref.78, p.1,2,4,7,8).

A Kleinfelder biologist conducted a preliminary two-day project site survey on May 31 and June 1 of 2006 to determine the presence of special-status plants and animals and their associated habitats. Based upon this two-day survey we identified potentially suitable habitat for three special-status species within the Redfish Bay system: White-faced Ibis (*Plegadis chihi*), Opossum Pipefish (*Microphis brachyurus*), and the West Indian Manatee (*Trichechus manatus*).

Although potentially suitable habitat for these special-status species occurs on and adjacent to the project site, this habitat does not guarantee the presence of or optimum use by special-status species. Additional species-specific focused surveys will be needed to ascertain these data.

Both federally listed and state listed species shall be addressed in the ecological risk assessment (ERA). In order to eliminate a threatened/endangered species as being potentially present, an ERA will provide supporting documentation from a wildlife management agency to confirm the absence of the protected species on the affected property. If this is not possible due to the time constraints associated with the project, a discussion will be provided on the lack of suitable habitat by comparing the available habitat with the habitat needs of threatened/endangered species that could possibly occur in the county. It will not be enough to simply assume that no protected species are known to occur at the Site.

If the presence or absence of a protected species cannot be determined, then the species will be considered as being present and potentially impacted. For species known to use the area or suspected to use the area due to habitat suitability, the ERA must then demonstrate through exposure or action level determination that the species will either not be impacted, or that protective cleanup levels will be developed. These demonstrations are usually accomplished by

calculating the exposure and evaluating the risk to a receptor that is a surrogate (a receptor from the same feeding guild) for the protected species. In this case, the ERA should also explain why the particular receptor chosen is a suitable surrogate for the sensitive species. Finally, where a protected species is known to occur or could possibly occur at the Site based on habitat suitability, any cleanup levels should be based on the NOAEL toxicity reference value (TRV).

The dominant plant species and ecological communities were observed on and adjacent to the project site and all observed fauna was recorded and listed in the following. Although plant species composition, density and percent cover vary throughout the project area, the on-site wetlands exist within areas that would commonly be referred to as coastal salt marshes or mudflats with moderate to low salinity levels. These plants do not fall into a precise plant community taxonomic structure but they can be closely associated with the Saltgrass-Cordgrass, Coastal Live Oak-Redbay, and Little Bluestem-Brownseed Paspalum plant community series, as described by Diamond (1993).

Once the Phase I data are evaluated, a site-specific habitat food web appropriate for the site will be finalized and presented in the ERA. Phases I and II of the RI/FS are discussed in more detail in this Work Plan and in the Field Sampling Plan and Quality Assurance Plan. As the media investigation progresses and RI/FS field activities occur, more information may become available regarding additional wildlife present at the site.

2.2.2 Definition of Sources of Contamination

The following section describes releases based on the medium of impact. The extent of any of the following releases has not been determined.

Detailed documentation of site-related hazardous substance contaminant releases to the environment is publicly available at the local repository:

Ingleside Public Library
2775 Waco Street
PO Drawer 400
Ingleside, Texas 78361

The following references from the HRS contain documentation related to this topic:

- Reference 9 (Texas Water Commission Solid Waste Compliance Monitoring Inspection Report, 6/05/86);
- Reference 10 (EPA Potential Hazardous Waste Site, Site Inspection Report, 12/14/87) proposes a sampling location in a nearby residential area located immediately northeast of the refinery;
- Reference 25 (Letter from TNRCC to NORCO; 2/23/96);

- Reference 30 (Memorandum from EPA's Region 6 Lab to the Office of Criminal Investigation, 3/27/96) provides the analytical results of the samples taken from Tanks N1 and N2 on February 15, 1996;
- Reference 33 (TNRCC, Oil or Hazardous Substances Discharge or Spill or Air Release Report; 11/15/95 [reported], 11/16/95 [date of report]) is a report documenting a 11/15/95 spill from a pipeline, operated by MJP Resources Inc., approximately one mile south southeast of FM 2725 on Bishop Road and adjacent to the Brown and Root Facility in a wetland area;
- Reference 34 (Telephone Memo to the File, From TNRCC to the Texas Railroad Commission [RRC]; 2/23/96) provides notification to the RRC that the spill that occurred from the MJP Resources pipeline (Reference 33) is under the jurisdiction of the TNRCC, based on analyses of the samples collected at the spill site;
- Reference 35 (Letter from TNRCC to MJP Resources Inc., 3/01/96);
- Reference 45 (Interoffice Memorandum, Texas Department of Water Resources, Reference a Temporary Pond to Store Treated Effluent [Permit 02142], 7/02/79);
- Reference 46 (Investigation Form, Texas Air Control Board, 4/23/87); and
- Reference 58 (Interoffice Memorandum, Texas Water Commission, 1/14/86).

The following alphabetical references are not from the HRS, they were provided by the EPA and are located in the repository:

- Reference A (Texas Parks and Wildlife Department; Fish Kill/Pollution Complaint Detailed Report; Start Date, 11/14/95) describes a pipeline spill by MJP Resources;
- Reference B (Texas Parks and Wildlife Department; Fish Kill/Pollution Complaint Detailed Report; Start Date, 04/16/02) describes a pipeline spill on land adjacent to a wetland;
- Reference C (Railroad Commission of Texas, Inspection Report, Initial Report dated 4/05/02) consists of several reports concerning the spill described in References B, D (TCEQ; Notice of Referral for the Hydrocarbon Release at Offshore Specialty Fabricators; 802 Sunray Road, Ingleside [San Patricio County], Texas; 9/09/02), and E (Photos Taken by the U.S. Fish and Wildlife Service on 9/18/02);
- Reference D (TCEQ; Notice of Referral for the Hydrocarbon Release at Offshore Specialty Fabricators; 802 Sunray Road, Ingleside [San Patricio County], Texas; 9/09/02);
- Reference E (Photograph Taken by the U.S. Fish and Wildlife Service on 9/18/02) provides a photograph of the spill area discussed in References B, C, and D;
- Reference F (Texas Parks and Wildlife Department; Fish Kill/Pollution Complaint Detailed Report; Start Date, 09/20/02) describes an oil spill from a storage tank (Tank #7, North Site);

- Reference G (TNRCC, Oil and Hazardous Substances Spill or Discharge Report, 9/20/02) consists of various reports and photographs of the tank leak described in Reference F;
- Reference H (Photograph Taken by TCEQ on 7/07/04) provides a photograph of Tank #27; and
- Reference I (Monthly Report of the EPA's Activities Concerning the CIP [Community involvement Plan], 10/19/04) provides the EPA's monthly report of CIP-related activities.

2.2.3 Nature and Extent of Contamination

Spills and releases at the site are discussed based on the medium of impact however in this section releases are described that impacted multiple mediums or involved hazardous substance sampling from tanks and Site investigations.

On January 13, 1987, the Texas Air Control Board (TACB) took a sample from a wastewater storage tank at Falcon Refining. Records indicate that the refinery received 104,000 bbls of material from Tenneco in January 1986. A substantial amount of this waste remained in the pipelines and tanks. TACB officials noted that noxious odor complaints from surrounding residents began when the refinery started processing this material. TACB concluded that the Tenneco material was not virgin petroleum, but a mixture of organic solvents and, probably, waste. TACB analytical results from a sample of material taken from a tank on January 13, 1987, support the conclusion that this material contained constituents not normally occurring in crude oil. Butanol, cyclohexanediol, 1 phenylethanol, N,N-diphenylamine, and xylene were detected in the sample of wastewater from the refinery.

The EPA Criminal Investigation Division (CID) of the Houston Area Office conducted a criminal investigation from January 1996, until August 2000, on the activities at GCC, a facility located north of the NORCO dock facility, which was being operated by MJP Resources, Inc. Specifically the investigation concerned a vinyl acetate slop stream delivered to GCC. According to Mr. Ronald Cady, Louisiana Department of Environmental Quality Regional Hazardous Waste Coordinator, and Mr. Brian Lynch, CID, this stream consisted of odorless mineral spirits (OMS) that were used as a carrier for the reactant in the production of polyethylene at Westlake Polymers in Sulphur, Louisiana. In this process, the mineral spirits are recycled until they become too contaminated to use and would be classed as a spent solvent. Westlake Polymers segregates the two streams and labels them V-240 (OMS) and V-242 (OMS with VA). In the past, they had been classifying the mineral spirits as a co-product. The vinyl acetate is not an excluded substance under the petroleum exclusion.

Samples were collected by the CID in February 1996 at the Site from two tanks (N1 and N2), also referred to as Tanks 32 and 33 in the main processing area of the NORCO facility. The liquid samples collected revealed high concentrations of vinyl acetate in these two tanks; 1,360,000 micrograms per liter (ug/L) and 36,600,000 ug/L.

Trucks delivered the liquid described in the previous paragraph from GCC to the Falcon Refinery pursuant to permission given by the MJP Resources, Inc. President, a previous lessee of the Falcon Refinery.

The hazardous substances identified on-site included such chemicals as nitric acid, acetic acid, cupric chloride, potassium chromate, silver nitrate and potassium hydroxide. Additionally, the EPA believes that hazardous wastes and residues identified by the RCRA waste numbers D002, K049 and K051 are also present. All of the hazardous wastes and substances are "hazardous substances" as defined by Section 101(14) of CERCLA, 42 U.S.C. § 9601(14), and CFR § 302.4.

2.2.3.1 Groundwater

Review of the project files indicates that only one groundwater sample has been obtained at the Site and that sample was taken immediately below the area of a spill from an above-ground storage tank (Reference 38).

Laboratory analyses received by the TNRCC Region 14 Office on February 25, 2000 revealed the following constituents; 1,2 dichloroethane, 4-methyl-2-pentanone (Ref. 38, p. 180), benzene, ethyl benzene, m,p,o-xylenes, styrene, and toluene (Ref. 38, pp. 44-50). The analyses also revealed that the fluid sample exceeded the maximum concentration of benzene for toxicity characteristic using the Toxicity Characteristic Leaching Procedure (TCLP).

The lone sample was obtained from a temporary monitor well and there are no boring logs or completion logs are available.

The existence of water wells adjacent to the Site is discussed in Sections 2.2.1.6 and 5.5.9.2 of this report.

The condition of the groundwater at the site will be determined during the RI/FS.

Adjacent to the northern property boundary of the storage and truck loading property, the Plains Marketing (Plains) site is in the Texas Commission on Environmental Quality (TCEQ) Voluntary Cleanup Program (VCP).

Three monitor wells (MW-1, MW-2 and MW-3) are installed immediately adjacent to North Site property fence (Appendix D). Review of the project file indicates the all three of these wells were impacted with hydrocarbons in 1995. However, this portion of the site has been excluded from the VCP program and these wells have not been sampled since they initially reported concentrations that indicated impacts.

Conversations with the TCEQ during June 2006 indicate that portions of the Plains site have should have been in corrective action and that additional sampling will be required of Plains. The data when available will be used in the RI.

A copy of the "Third Quarter 2005 Groundwater Monitoring Report, Plains Marketing Terminal, Ingleside, Texas, VCP No. 449", which was submitted to the TCEQ is included in Appendix E. The report includes analytical data summaries for the 19 monitor wells that are in the VCP program. Missing from the analytical summaries are data for monitor wells MW-1, MW-2 and MW-3, the monitor wells that were installed immediately adjacent to the North Site and had documented contamination in 1995.

2.2.3.2 Soil

This section includes in chronological order a description of the documented spills, discharges or the disposal of product or waste to the soil at the site.

On February 14, 1979, the TACB performed an inspection of the UNI Refinery in response to complaints of odors that were emanating from the facility. During the inspection two separate spills were noted and are depicted in Figure 8. The significant source of the odors was an accidental spill, which emanated from Tank 17, which stored slop oil. The spilled slop oil migrated to the east and entered the areas around Tanks 14, 13 and 12.

The second odor source from the 1979, TACB inspection was associated with open pit bottom sediments from Tank 15. Mr. Hodge, the Plant Manager, indicated that a shipment of crude oil from Nigeria was found to have an unexpected amount of bottom sediments and with no place to store the material the sediments were pumped into the diked area around Tank 15.

On June 17, 1979, Gene Hodge called the called the Texas Department of Water Resources (TDWR) to inform them that during the construction of a permitted temporary pond (Permit 02142), which was to be used to store treated effluent, oily ground was uncovered. The Site (Figure 9) and oily ground was inspected and photographed by the TDWR. Based on the record, the source of the oil was from a previous owner of the property that had probably disposed of basic sediment and waste (BS&W) and oily waste.

The refinery, when active processed material that consisted of not only crude oil but also contained hazardous substances, as defined by 40 CFR Part 261.32. In a Notification of Hazardous Waste Activity, signed on October 20, 1980 by Mr. Eugene W. Hodge (Vice President of UNI Refining, Inc.), four hazardous wastes from specific sources were listed: K048 (dissolved air flotation float), K049 (slop oil emulsion solids), K050 (heat exchanger bundle cleaning sludge), and K051 (API separator sludge). Of these sources, the listed hazardous waste K051, API separator sludge from the petroleum refining industry based on the toxicity of the sludge, was documented in an inspection report to have been deposited inside the walls of a tank berm. Other hazardous substances at the site included: vinyl acetate detected inside tanks during an EPA CID criminal investigation and a TNRCC Region 14 sampling event, chromium detected in deposited cooling tower sludges and untreated wastewater releases inside tank berms.

On January 9, 1982, during an annual solid waste compliance inspection by the TDWR, under Solid Waste Registration 31288, small quantities of separator sludge had been put in a "waste pile" on the northwest side of the berm for Tank 30 (Figure 10). After being informed of the violation, the record indicates that UNI would remove the small amount deposited and ship all API sludges off-site in the future. There is a letter from the TDWR indicating that in fact the sludge had been shipped off-site to Chemical Waste Management in Port Arthur, Texas.

During December 1985 a 100,000-bbl run of slop oil was received at the refinery. At the time the refinery's wastewater treatment system was inoperable and the untreated wastewater was stored in tanks and ultimately discharged into sandy unlined containment structures (firewalls). The location of the released wastewater was noticed during a solid waste compliance inspection by the Texas Water Commission (TWC) on March 12, 1986 (Figure 11).

On January 13, 1986, TACB took a sample from a wastewater storage tank at the Site. Records indicate that the refinery received 104,000 bbls of material from Tenneco in January 1986. A substantial amount of this waste remained in the pipelines and tanks. TACB officials noted that noxious odor complaints from surrounding residents began when the refinery started processing this material. TACB concluded that the Tenneco material was not virgin petroleum, but a mixture of organic solvents and, probably, waste. TACB analytical results from a sample of material taken from a tank on January 13, 1987, support the conclusion that this material contained constituents not normally occurring in crude oil. Butanol, cyclohexanediol, 1 phenylethanol, N,N-diphenylamine, and xylene were detected in the sample of wastewater from the refinery.

During the annual solid waste inspection, which was performed on March 12, 1986, the inspectors noted that there were approximately 30 drums located in various locations of the refinery. West of Tank 31 there was 21 drums with bullet holes and spilled material. However, only four appeared to contain material.

The March 12, 1986, inspection also revealed that the Falcon Refinery had disposed of cooling tower sludges on-site. These sludges were sampled and the laboratory reported Total Chromium of 8020 milligram per kilogram (mg/kg) and an EP Tox Chromium of 46 micrograms per kilogram (ug/kg). The inspector noted that, during December 1985, the Falcon Refinery made a 100,000 bbl run of slop oil, which generated a substantial amount of very odorous wastewater. The refinery's wastewater treatment system was inoperable during this run. The refinery placed untreated wastewater in tankage and then, ultimately, discharged the untreated wastewater into sandy, unlined containment structures (firewalls). According to a 1986 inspection report, the untreated wastewater was discharged into the bermed areas around tanks 10, 11, 26, and 27. A sludge, which had been dumped inside the firewalls of tank 13, was observed and sampled during the inspection of July 1986, by TNRCC Region 14 staff. Constituents found in the sample included naphthalene, 2,4-dimethylphenol, acenaphthene, fluorene, phenanthrene, fluoranthene, pyrene, and chrysene.

During the same inspection a sample of the cooling tower sludge was obtained by the TWC and analyzed. The results indicated that the total chromium concentration was 8020 parts per million (ppm), which indicated that the sludge was non-hazardous. Oily sludge was also noted around Tank 13.

On April 9 and 10, 1987 the TACB investigated three odor complaints that were received concerning the Falcon Refinery. An on-site inspection revealed a black liquid substance beneath a pipe rack within the refinery. The liquid, which appeared to be a solvent with hydrocarbon/carbon or a crude oil with solvent intermixed, was leaking from the third pipeline from Bishop Road, which was a 10-inch pipeline that connects the tank farm in the refinery to a run-of-pipe from the docks. The final spill covered an area approximately 30 feet by 60 feet.

On April 17, 1987, the repair was made to the pipeline and on April 21, Bernie Duncan of ARM Refining indicated that they used a bulldozer to cover the area and eliminate odors. He indicated that he would watch the area to see if the product seeped to the surface.

On January 4, 2000, TNRCC Region 14 inspectors completed a compliance inspection pertaining to the air quality requirements for permitted tanks. These tanks are located on the northwest quadrant of the FM 2725 and Bishop Road and are authorized in three active TNRCC air permits. The naphtha stabilizer unit, located in the main processing area in the southeast quadrant of FM 2725 and Bishop Road, was observed to be leaking from a valve between the sight glass and the tank. This valve was approximately 20 feet high and the wind was blowing a shower of leaking fluid on to an area of soil and vegetation surrounding the tank. Two 8-ounce jars of sample were collected of the liquid as it leaked from the valve. Based upon the flow rate of the leak observed on January 7, 2000, and the site inspections conducted on January 4, 6, 7, 10, and 11, 2000, it was determined by the TNRCC Region Office that a total volume of at least 220 gallons of material had leaked from the tank.

On September 20, 2002, after a heavy rain, Tank 7 from the North Site overflowed and somewhere between 500 gallons and 500 bbls of crude oil (the document record includes both amounts) was estimated to have been spilled. The crude oil filled the bermed area around the tank and spread to the east toward Hwy 2725. The spilled material got to the east side of Hwy 2725 and eventually flowed in the drainage ditch toward Bishop Road and then followed the drain ditch east along Bishop Road.

NORCO hired Miller Environmental (Miller) to respond to the release and Miller used vacuum trucks and absorbent pads to remove as much of the spilled material as possible. After the free liquid was removed, Miller excavated the impacted soil, sampled the area and replaced the soil. Sampling of the soil met TCEQ closure requirements. Reports describing the release are included in Appendix F**.**

Some of the crude oil that traveled along the drainage ditch on Bishop Road was deposited on Brenda Shedd's driveway on Thayer Road. Much of the impacted area has since been paved. During 2004, after heavy rain, Mr. Salinas on Bishop Road noted a sheen in the drainage ditch near their home.

Heavy rain also caused Tanks 26 and 27 at the refinery to overflow, spilling oily waste onto the ground. Since that time NORCO has been removing the contents of the tanks and they are both 80% empty at the time of the submission of this work plan and there is no chance that the tanks will overflow.

Results of the on-site sampling, which are reported in the HRS, revealed that the Site had five source areas and each will be discussed in the following paragraphs. The five source areas are considered part of the Operating Units (OU) of the refinery and are all within Area of Concern (AOC) 1.

Source Area 1 was sampled to evaluate the discharge of refinery process wastewater plus other refinery effluent streams and runoff to an outlet located in Corpus Christi Bay. Samples SO-18, SO-22 and SO-23, collected from Source Area 1, were analyzed for Volatile Organics, Semi-Volatile Organics, Metals/Cyanide and Pesticides/Polychlorinated biphenyls (PCBs).

Source Area 2 was sampled based on a note from the 1996, inspection that noted that there was an area designated in 1981, as "dumped benzene." No visual evidence of such an activity exists.

Source Area 3 was sampled to evaluate the main process area of the refinery and several known releases.

Source Area 4 was sampled to evaluate API separator sludge that was deposited inside the walls of a tank berm.

Source Area 5 was sampled to evaluate the dumping of cooling tower sludge on the ground.

Information on the soil samples, collected for purposes of the HRS, can be found in the HRS Documentation Record for the Site.

2.2.3.3 Surface Water

During an EPA inspection of the refinery on December 14, 1987, there is a note in the record that surface water samples were obtained from the lined lagoon, effluent from the process area drain system, water from southeast of the Site, background from Redfish Bay, and at a duplicate-appropriate location. There is a column for concentration and the result for all of the samples says "low". Actual laboratory analyses are not part of the record.

Surface water in the wetlands was impacted by a spill from an ARM Refining spill in 1985. The spill is discussed in the section 2.2.3.4.

2.2.3.4 Sediment

This section includes in chronological order a description of the documented spills that impacted the wetlands and sediment at the site.

During the inspection at the Plains Marketing (formerly ARM Refining) facility in December 1985, the TWC documented an oil spill from an ARM pipeline, which caused pollution to the surface waters of the State (Ref.58, pp. 2-3) (Figure 12). During this time, ARM's operations consisted of reclaiming waste oil from drilling site pond skim and used lubrication oil from various sources. The possible location of the spill was provided based on eye witness accounts and the current location of the Plains Marketing's pipeline which leads to their current docking facility.

Review of TCEQ files at the District Office in Corpus Christi and at central records in Austin did not reveal any information about cleanup activities associated with ARM spill in the wetlands.

On November 15, 1995, a spill was reported south-southeast of FM 2725 on Bishop Road, in the wetlands adjacent to the Brown & Root Facility (Figure 13). The spill occurred during a hydrostatic test of a pipeline prior to bringing the line back into service. The underground pipeline runs from the dock facility to the main facility. Approximately less than eight barrels of "crude oil" were spilled. According to Mr. Bernie Eickel of the Railroad Commission of Texas (RRC), the sample analyses on February 7, 1996, indicated the presence of substances other than crude oil. Two contaminated soil piles and two roll-off containers containing regulated waste associated with the spill resulted from the waste removal activity. Analyses of the February 7, 1996, samples (collected from one roll-off and liquid material leaking from the roll-off) indicated constituents not normally found in crude oil and elevated levels of the following constituents: tetrachloroethene, 2-methylnapthalene, phenanthrene, toluene, and total xylenes.

On February 16 and 19, 1996, an inspection was conducted by the TNRCC Region 14 staff at the NORCO facility in response to an alleged crude oil pipeline spill from the facility on November 15, 1995. Analysis of the spilled residuals revealed constituents not naturally occurring in crude oil. Mercury, lead, 1,2, dichloroethane, benzene, ethyl benzene, styrene, toluene, total xylenes, chrysene, m-creosol, o-creosol, p-creosol, fluorene, methyl isobutyl ketone, 2-methylnaphthalene, naphthalene, phenanthrene, pyrene, methyl tert-butyl ether, total organic halogens, and vinyl acetate were detected in the samples collected. Vinyl acetate was detected in tanks N1 and N2. Vinyl acetate is not an ingredient in crude oil nor does it substitute for other products, as it has no solvent properties, thus exempting the chemical from the petroleum exclusion.

On April 4, 1996, Jones & Neuse conducted grid sampling at the spill site (Figure 13 –MJP Pipeline Spill). The samples were analyzed for benzene, toluene, ethyl benzene, and xylene (BTEX) and total petroleum hydrocarbons (TPH). No BTEX content was detected in the soil samples taken, but TPH levels were detected ranging from 67 to 1930 mg/kg. The TNRCC limited sampling parameters to BTEX and TPH to obtain closure for the site. Closure was

ultimately granted based on no visible evidence of spilled material. Analyses for other hazardous substances, pollutants or contaminants were not performed even though other chemicals, not naturally occurring in crude oil, were spilled in the event.

On April 4, 2002, there was a spill of approximately 20 gallons of crude oil on property owned by Offshore Specialty Fabricators (Reference C on the CD provided by the EPA describing spills). The spill was in the wetlands north of Sunray Road (Figure 14). On July 29, 2002, the Texas Natural Resources Conservation Commission (TNRCC) issued a letter to Mr. Dickey Henderson (Offshore Specialty Fabricators, Inc.), which indicated that the apparent cause of the release is a series of abandoned pipelines on Offshore Specialty's property. A RRC report dated April 4, 2002, states that employees dug a hole approximately twelve (12) feet deep and found no clean sand. Samples of the liquids present at the spill, taken by the RRC on April 15, 2002, were analyzed and revealed the presence of vinyl acetate. A RRC report dated April 16, 2002, states that additional seepage was found from suspected unknown pipelines approximately 10 feet from the water of the salt marsh on the north end of Sunray Road. According to the RRC report, the lines were suspected to be UNI (a previous owner of the Falcon Refinery) lines.

Information on the sediment samples, collected for purposes of the HRS, can be found in the HRS Documentation Record for the Site.

2.2.3.5 Air

This section will describe air permitting, complaints dealing with the air, and inspections relative to emissions.

Review of project files provides the following information dealing with air, the TACB and TNRCC Office of Air Quality. The facility was constructed initially under TACB permit C-5243, which was assigned to the Oil and Gas Company of Texas, Inc. as a petroleum product storage facility. The facility was then sold to UNI Oil, Inc. and permit C-6879 was added for additional storage.

In 1977, UNI Oil, Inc then applied for a permit (C-6027) to construct a 10,000 bbl per day crude topping plant with associated tankage, truck loading and barge dock. Additional storage was then added under permit numbers C-6607 and C-6027. The TACB issued a letter dated June 13, 1978, that indicated that the construction that was being performed at the Site was a violation. On June 14, 1978, UNI Oil, Inc applied for the construction of an additional 30,000 bbl per day crude distillation unit.

While reviewing the application for the new unit, the TACB held a public meeting with area residents. During the meeting there were several complaints concerning UNI Oil, Inc's operations, however, the complaints, which dealt with the dust and speeding trucks, were out of the jurisdiction of the TACB.

A complaint was called in to the TACB on August 22, 1978, about odors at the Site. When the investigator arrived at the Site, the odors were no longer present and no contact was made with UNI Oil, Inc.

On February 14, 1979, a nearby resident complained about odors emanating from the UNI Oil facility. The odors were verified by a TACB inspector and Gene Hodge, the plant manager, indicated that the source of the odor was an accidental spill from slop tank No. 17. An additional odor was also detected during a follow up Site investigation and the source of that odor was an open pit of bottom sediments around tank No. 15. According to Mr. Hodge, a crude oil shipment from Nigeria was found to have an unexpected amount of bottom sediments. With no place to store the unusable material the bottom sediment was pumped into the diked reservoir.

On December 30, 1985, a resident complained that they had experienced odor problems off and on for the last week. An investigation was conducted the following day and a strong caustic/mercaptan odor was noted. The facility was now known as Falcon Refining. A Site inspection revealed that only one person, a consultant, was at the facility and he indicated that Falcon had refined some 7,000 bbls in check-out runs. The consultant was notified that the odors were a violation and that a notice would be issued.

On January 10, 1986, another complaint was received and investigated by the TACB. During the inspection a sweet, “varnish-type” odor was detected from several cone-roofed storage tanks located behind the office. Mr. Richey, the Plant Manager, indicated that the refinery had not run since the night/morning of January 7/8 and would not run until the issue of change in ownership was resolved. He also noted that the odor was from the storage of water that was produced during the refining run of the Tenneco feedstock. On the 13th a sample of the material was obtained and hand-carried to Austin on the 14th. During the sample collection, the odor was again noted.

Results of the sample indicated that presence of xylene, butanol, cyclohexanediol and 1 phenylethanol.

On April 9 and 10, 1987, the TACB investigated three odor complaints that were received concerning the Falcon Refinery. The investigators reported that a strong odor of phenol and/or oxygenated alcohol hydrocarbon or solvent were evident and that the vapors caused irritation of the nasal passages and mucous membranes. On-site inspection revealed a black liquid substance beneath a pipe rack within the refinery. The liquid, which appeared to be a hydrocarbon solvent or a crude oil with solvent intermixed, was leaking from a 10-inch pipeline that connects the tank farm in the refinery to a run-of-pipe from the docks.

On December 28.1995, MJP Resources Inc. sent a letter to the TNRCC Office of Air Quality to modify the existing air permits. The plan called for the use of two existing 55,000 bbl internal floating roof tanks and two 20,000 bbl tanks to be used to store crude oil from barges.

2.2.4 Additional Site Characterization

The most significant immediate threat to the environment from the Site is the waste that is stored in the above-ground storage tanks, which will be a central focus of the Removal Action.

2.2.4.1 Potential Off-Site Sources

Plains Marketing lies adjacent to the northern section of the Falcon Refinery (Ref. 57, p. 3). This facility was a crude oil topping facility with a production capacity of 10,000 bbls per day and now operates as a petroleum storage and transfer terminal (Ref. 57, p. 6). During the inspection at the Plains Marketing (formerly ARM Refining) facility in December 1985, the TWC documented an oil spill from an ARM pipeline that caused pollution to the surface waters of the State (Ref. 58, pp.2-3). During this time, ARM's operations consisted of reclaiming waste oil from drilling site pond skim and used lubrication oil from various sources.

Much of the facility has been assessed and evaluated through the VCP under the TCEQ. The Plains site has 19 monitor wells, which have quarterly gauging and sampling data dating back to 1996 (Appendix E). September 2005 analytical data indicate that samples from monitor wells (MW-17) which formerly exceeded the drinking water standard for benzene, is located across FM 2725 from where the release occurred.

Monitor wells MW-1, MW-2, MW-3 and MW-4 (Appendix D), which are not included in the area that is defined by the VCP, are located immediately adjacent to the North Site. Review of the project file at the TCEQ indicates that these monitor wells were only sampled once in November, 1995 and that the analytical results for MW-1, MW-2 and MW-3 indicated that the groundwater was contaminated.

These monitor wells are immediately upgradient of the North Site and the possibility exists that the groundwater underlying the NORCO facility may have been impacted. This possibility will be investigated during the RI/FS planned for the site.

To the south of the Falcon Refinery, the Garrett Construction Company is located at Garrett Road and FM 2725 in Ingleside. A TNRCC file review revealed air permit exemptions regarding a sand and gravel screening plant, an outdoor dry abrasive blast facility, and a rock crusher unit it for this construction company (Ref. 60, p. 1-5).

Aker Gulf Marine - Aransas Pass Yard is located northeast of the Falcon Refinery (Figure 6). Aker Gulf Marine is a fabricator of offshore structures and other petroleum related structures for the oil and gas industry (Ref.61, p.5). The Aransas Pass Yard is the site where structural components are fabricated (Ref. 61, p. 6). This facility has a permitted discharge point into the Intracoastal Water/Redfish Bay under Texas Pollutant Discharge Elimination System (TPDES) permit (Ref. 62, p. 1).

IBC Petroleum and Pi Energy were located immediately northwest of the Dock Facility (PPE-2). Sample SO-05 (F02JJ/MF00P3) (Ref.42, pp.67-69; Ref.43, p.20) was taken northwest of the NORCO dock facility. The soil sample location was collected at the location of leaking equipment on the IBC Petroleum property. The constituents detected in that sample were not detected in the samples collected adjacent to the dock facility, SE-30 (F02JA/MF00NT) (Ref.21, pp. 9, 11, 12, 21; Ref. 16,pp. 9, 15, 25) and SE-31 (F02JB/MF00NW) (Ref. 21, pp. 9, 11, 12,40-42, 73-78; Ref. 16, p. 9, 16, 26).

Alamo Concrete Products, LTD., (formerly Coast Materials, Inc.) is an inactive concrete batch plant located northeast of the NORCO dock facility and north of Sunray Road (Ref. 63, pp. 1-2; Ref. 64, p. 1). The type of air contaminants associated with Coast Materials, Inc. included fly ash, cement, cement and aggregate, and dust (Ref. 65, p. 1).

Brown & Root, Inc. was located off of Bay Avenue and Bishop Road (Figure 6) (Ref. 66, p. 1). There has been minor soil contamination resulting from a Leaking Petroleum Storage Tank (LPST). However, the case was closed by TNRCC (Ref. 67, p. 1). Brown & Root applied for an air permit relating to abrasive blast cleaning in May 14, 1985 (Ref. 68, p.1). No wastewater discharge permit was located for this facility.

Ingleside Properties, Inc. a.k.a. Dugat Docks is a facility located at the end of Bishop Road and the North Bank Terminal on the Intracoastal Waterway / Redfish Bay. The operation described in the permit application is as a drilling fluids chemicals terminal and oil field waste treatment plant (Ref. 69, p. 1).

GCC was located on the Intracoastal Waterway / Redfish Bay north of the NORCO/MJP Resources, Inc., dock facility and south of Aker Gulf Marine (Figure 6). The site is now owned by Offshore Specialty Fabricators. On December 2, 1995, a spill occurred of approximately 170 gallons of unknown petroleum hydrocarbon at the GCC (Ref. 72, p. 1). The report states that there was not any receiving water for the spill. Acetone, chloromethane, and methyl ethyl ketone (2-butanone) were detected in a soil sample collected on September 18, 1996 (Ref. 71, pp 3-6). The contaminated soil was removed from the site (Ref. 70, pp. 1-2).

On January 4, 1996 TNRCC staff went to the GCC site and sampled the ASTs. Results of the analyses indicated that vinyl acetate was detected in the storage tanks.

3.0 INITIAL EVALUATION

Conceptual Site Models (CSMs) for human and ecological receptors have been developed; these are based on the results of preliminary site investigations and other data. Both are summarized in the CSM Flowchart for Human & Ecological Receptors (Figure 15), which shows potential exposure and migration pathways and receptor scenarios to be considered in developing human health and ecological risk evaluations for site contaminants under existing and future conditions. The CSM Schematic for Human Receptors (Figure 16a) and the CSM Schematic for Ecological Receptors (Figure 16b) depict the general features of these exposure scenarios in a non-technical manner

designed to be readily comprehended by any viewer. The CSMs, the CSM Flowchart, and the CSM Schematics will be refined as necessary during implementation of the Data Quality Objectives (DQO) Process.

3.1 Types and Volumes of Waste

Waste at the Site consists of liquid and sludge in the above-ground storage tanks, piping and abandoned sumps, material left in drums that were abandoned at several locations at the site and impacted soil.

During September 2004 there were approximately 50 abandoned drums at the site. Since that time all drums were properly sampled, characterized and disposed.

3.1.1 Type of Waste

Previous analytical sampling of the above-ground storage tanks (at NORCO and adjacent facilities), soil sampling, sediment sampling, surface water sampling and groundwater sampling have identified the constituents listed in Section 3.3.

3.1.2 Volume of Waste

All of the above-ground storage tanks were examined and the contents of the tanks sampled during August and September 2004. The results indicated that approximately 6.9 million gallons of hazardous waste was in the tanks. As of April 2007 NORCO had disposed of approximately 6.05 million gallons of the waste leaving approximately 850,000 gallons in the above-ground storage tanks.

NORCO continues to remove and dispose of this hazardous waste and plans to dispose of all hazardous waste in these tanks by December 2007.

3.1.3 Pipeline Abandonment

Residual liquids in on-site above-ground piping have been removed as well as a portion of the liquids in the abandoned underground pipelines that connect the refinery to the former and current barge dock facilities. Disposal activities associated with the RA are described on a monthly basis in the Monthly Progress Reports.

On August 6, 2007, Addendum No. 2 of the Removal Action Work Plan (Appendix G) was prepared and submitted into the document record. The report, which describes the abandonment of ten pipelines associated with the refinery, is summarized in the following paragraphs.

Ten of the service pipelines were cut and capped at the point where they travel underground, close to the intersection of Bishop Road and Bay Avenue. Near the intersection of Sunray Road and Bay Avenue the ten pipelines were twice cut again and a section was removed from each.

After the pipelines were either pigged clean or vacuumed to remove all contents, they were capped with welded-on steel plates or by some other means. In total approximately 8,400 gallons of hydrocarbons and water were removed from the pipelines and placed in Tank 26 on the refinery property.

During May 2007 a second assessment will be performed to ensure that all liquids are removed from the pipeline segment that runs from Sunray Road to the former barge dock facility.

The area of the abandoned pipelines will be further evaluated during the RI/FS.

3.2 Potential Pathways of Contaminant Migration

As shown in the CSM Flowchart (Figure 15), the potential migration pathways for site contaminants include volatilization to outdoor air, leaching from soils to groundwater, generation of fugitive dusts in outdoor air, and storm-water runoff. The (BHHRA) Baseline Human Health Risk Assessment and the Ecological Risk Assessment will address the migration pathways described in the CSM Flowchart.

3.3 Potential Applicable or Relevant and Appropriate Requirements (ARARs)

CERCLA §121(d) specifies that on-site Superfund remedial actions must attain federal standards, requirements, criteria, limitations, or more stringent state standards determined to be legally applicable or relevant and appropriate to the circumstances at a given site. Such ARARs are identified during the remedial investigation/feasibility study (RI/FS) and at later stages during the remedy-selection process. For removal actions, ARARs are identified whenever practicable depending upon site circumstances. To be applicable, a state or federal requirement must directly and fully address the hazardous substance, the action being taken, and other circumstances pertinent to the site. A requirement which is not applicable may be relevant and appropriate if it addresses problems or pertains to circumstances similar to those encountered at a Superfund site.

Both chemical-specific and location-specific ARARs will be identified during the RI process and will be discussed with the project team during the Phase I scoping meeting after the Phase I data are gathered and the screening-level analysis is complete. Potential sources of chemical-specific ARARs include:

- Safe Drinking Water Act (42 U.S.C. 300(f)):
  - Maximum Contaminant Levels (MCLs) for chemicals, turbidity, and microbiological contamination; applicable to drinking water for human consumption (40 CFR 141.11-141.16).
  - Maximum Contaminant Level Goals (MCLGs) (40 CFR 141.50-141.51, 50 FR 46936).
- Clean Water Act (33 U.S.C. 1251) requirements established pursuant to sections 301 (effluent limitations), 302 (effluent limitations), 303 (water quality standards, including

State water quality standards), 304 (Federal water quality criteria), 306 (national performance standards), 307 (toxic and pretreatment standards, including federal pretreatment standards for discharge into publicly owned treatment works, and numeric standards for toxics), 402 (national pollutant discharge elimination system), 403 (ocean discharge criteria), and 404 (dredged or fill material) of the Clean Water Act, (33 CFR Parts 320-330, 40 CFR Parts 122, 123, 125, 131, 230, 231, 233, 400-469).

- Marine Protection, Research, and Sanctuaries Act (33 U.S.C. 1401).
- Toxic Substances Control Act (15 U.S.C. 2601).
- Resource Conservation and Recovery Act (40 CFR Parts 260-279).
- Applicable TCEQ guidelines, TRRP rules and any other standards specific to the state of Texas.

A preliminary list of potential location-specific ARARs is presented below in Table 3.3A.

Table 3.3A Potential Location-Specific ARARs

Location	Citation
Within 100-year floodplain	40 CFR 264.18(a)
Critical habitat upon which endangered species or threatened species depend	Endangered Species Act of 1973 (16 USC 1531 et seq.) 50 CFR Part 200, 50 CFR part 402 Fish and Wildlife Coordination Act (16 USC 661 et seq.)
Wetlands	Clean Water Act section 404; 40 CFR Parts 230, 33 CFR Parts 320-330.
Within coastal zone	Coastal Zone Management Act (16 USC 3501 et seq.)

Following is a preliminary list of the chemicals of potential concern (COPCs) that have been identified on or near the site and for which we expect to develop chemical-specific and location-specific ARARs. The chemicals are organized by chemical class into three categories: volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and metals. Maximum contaminant levels (MCLs) have been identified for the chemicals that are underlined and these values are provided in Appendix I.

- **VOCs:**
  Benzene, Butanol, Cyclohexane, Cyclohexanediol, 1,2-Dichloroethane, Ethylbenzene, Ethyl ether, Hexane, Isopropylbenzene, Methyl ethyl ketone, Methyl isobutyl ketone, 4-methyl-2-pentanone, Methyl tert-butylether, N-diphenylamine, N-propylbenzene, 1-phenylethanol, Styrene, Tetrachloroethylene, Toluene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, Vinyl acetate, and Xylenes.

- **SVOCs:**
  Acenaphthene, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(g,h,i)perylene, Benzo(a)pyrene, Chrysene, 2,4-Dimethylphenol, Fluoranthene, Fluorene, Indeno(1,2,3-cd)-pyrene, 2-Methylnaphthalene, 2-Methylphenol, 3-Methylphenol, 4-Methylphenol, Naphthalene, Phenanthrene, and Pyrene.

- **Metals:**
  Aluminum, Arsenic, Chromium, Copper, Lead, Manganese, Mercury, Nickel, Thallium, Vanadium, and Zinc.

4.0 WORK PLAN RATIONALE

Data collection, which is described in detail in the FSP, is designed to meet the objective of obtaining the required data to evaluate the human health and ecological risks associated with the site.

Due to the lack of 1) data concerning the current contents of the ASTs, 2) delineation of any of the spills or releases, 3) information concerning groundwater at the site and 4) information as to the variety of spilled compounds, the RI involves uniform analytical testing that is designed to identify any areas of specific concern.

5.0 RI/FS TASKS

5.1 Field Investigation

This is addressed in the RI/FS Sampling and Analysis Plan.

5.2 Sample Analysis/Validation

This is addressed in the RI/FS Sampling and Analysis Plan.

5.3 Data Evaluation

This is addressed in the RI/FS Sampling and Analysis Plan.

5.4 Community Relations

The EPA conducted door-to-door interviews with local residents living within one mile of the Site in October 2002 to gather information about the site. The EPA also met with the City Manager of Ingleside to discuss the status of the Site. On October 12, 2004 the EPA met with San Patricio County Commissioners and local residents living immediately adjacent to the Site to provide an update of site activities and to discuss concerns that were voiced during the community meeting held on September 16, 2004 at the Ingleside City Hall. Community involvement activities are described in the Community Involvement Plan (CIP), prepared by the

EPA for the site, which is updated on a regular basis. The CIP is located at the Ingleside Public Library.

To keep the public informed, NORCO and the EPA held a community meeting on September 16, 2004 to discuss current and planned activities for the site. A fact sheet announcing the meeting was mailed to over 250 individuals and entities. Newspaper announcements were "public noticed" in the Corpus Christi, Ingleside and Port Aransas newspapers, prior to the community meeting, which encouraged the public's participation.

The following are notes from EPA interviews of residents on Thayer Road and Bishop Road.

> On 10/12/04 at 3 pm the EPA met with Debbie Belt (113 Thayer Circle, Rt. 1 Box 481-I, Ingleside TX) to discuss her water well located immediately south of FM 2725. The EPA had interviewed her in late 2002. She informed them that she has not noticed any odor/contamination problems with the water from her well and stated that the water tastes good to her.
>
> On 10/12/04 at 3:20 pm the EPA met with Brenda Shedd (Thayer Road). Her property is located immediately northeast adjacent to the refinery. She had previously filed several complaints with the State about the refinery activities. She stated that on one occasion an oily substance spilled onto her backyard from a leak at the refinery. On another occasion she stated that she observed refinery workers pumping liquids that had spilled onto the ground at the refinery into the wetland area to the northeast of the Site and behind her property. She stated that she had reported both incidents to the TNRCC and investigators had come to the site.
>
> On 10/12/04 at 5 pm the EPA met with Brenda Carroll (1322 Sunray Road), upon her request by telephone to the EPA Community Involvement Coordinator, to discuss her water well. She stated that she no longer uses the well (they are on city water now) because of hydrocarbon odors. Her husband stated that they had it tested and the well water showed elevated levels of barium. This water well is located across Sunray Road from Plains oil storage facility, most probably upgradient of the Falcon Site. They were referred to the TCEQ.

The EPA awarded a Technical Assistance Grant (TAG) to the Coastal Bend Bays Foundation (CBBF) on December 14, 2004. Mrs. Lois C. Huff, the Executive Director for the CBBF, can be reached at (361) 882-3439 or at the internet address www.baysfoundation.org. The purpose of a TAG is for a local citizen's group to secure the services of a technical advisor (TA) to increase citizen understanding of information that will be developed about the site during the Superfund process. The EPA and NORCO will work closely with the TA and will provide the necessary documentation for his/her review.

All project documents are publicly available at the local repository:

> Ingleside Public Library

2775 Waco Street
PO Drawer 400
Ingleside, Texas 78361

5.5 Baseline Human Health Risk Assessment Work Plan

The BHHRA Plan provides an overview of the methods to be used in conducting the BHHRA for the Site located in Ingleside, San Patricio County, Texas. Further information on the site location and history is presented in Section 3.

5.5.1 General Site Description

The Site consists of an approximately 104-acre refinery that operated intermittently and is currently inactive. It is located near Ingleside, Texas in San Patricio County, Texas at the north and south corners of the intersection of FM 2725 and Bishop Road. When in operation, the refinery had a capacity of 40,000 bbls per day and the primary products consisted of naphtha, jet fuel, kerosene, diesel and fuel oil. Another portion of the site includes a dock facility on Redfish Bay, where materials were transferred between barges and storage tanks. The Site is bordered by wetlands to the east, northeast and southeast, residential areas to the north and southwest, and construction companies to the south and north.

5.5.2 BHHRA Objectives

The primary objective of the BHHRA is to evaluate and assess potential risks to human health posed by chemicals present on or originating from the Site, in the absence of any remedial action. The principal guidance documents that have been used to prepare the BHHRA plan are:

Risk Assessment Guidance for Superfund (RAGS) (Parts A, B, C, D, and E) (EPA 1989, 1991a, 1991b, 1998, and 2004).

Supplemental Guidance to RAGS: Standard Default Exposure Factors (EPA 1991c).

Exposure Factors Handbook (EPA 1997a).

Guidance for Data Usability in Risk Assessment, Office of Emergency and Remedial Response. OSWER Directive No. 9285.7-09A. April 1992 (and Memorandum from Henry L. Longest dated June 2, 1992) (EPA 1992).

EPA Region 6 Risk Assessment Guidance (EPA 1995).

EPA Region 6 Media Specific Screening Levels (EPA 2007).

TCEQ Regulatory Guidance: Determining PCLs for Surface Water and Sediment. RG-366/TRRP-24 (Revised) December 2002 (TCEQ 2002)

TCEQ Protective Concentration Levels (TCEQ 2007).

Additional EPA guidance documents will be used as necessary to supplement the principal guidance documents.

In accordance with EPA guidance, the four steps of a baseline risk assessment are:

- Data Collection and Evaluation – This step of the process involves gathering and analyzing the site data relevant to the human health evaluation and identifying the substances present at the site that are the focus of the risk assessment process.
- Exposure Assessment – An exposure assessment is conducted to estimate the magnitude of actual and/or potential human exposures, the frequency and duration of these exposures, and the pathways by which humans are potentially exposed.
- Toxicity Assessment – The toxicity assessment component of the baseline risk assessment considers: 1) the types of adverse health effects associated with exposures to the chemicals of potential concern; 2) the relationship between magnitude of exposure and adverse effects; and 3) related uncertainties such as the weight of evidence of a particular chemical's carcinogenicity in humans.
- Risk Characterization – The risk characterization summarizes and combines outputs of the exposure and toxicity assessments to characterize baseline risk, both in quantitative expressions and qualitative statements. During risk characterization, chemical-specific toxicity information is compared against both measured contaminant exposure levels and levels predicted through fate and transport modeling to determine whether current or future levels at or near the site are of potential concern.

Final Risk Assessment Reports will follow the approach described in the EPA's guidance document entitled "Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual [Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments], Interim, Publication 9285.7-01D, January 1998".

In accordance with the Order for the Site, a Draft BHHRA will be prepared and submitted to EPA for review and approval according to the schedule specified in the Final RI/FS Work Plan. An Amended Draft BHHRA Report will be submitted 45 calendar days after the receipt of the EPA's comments on the Draft BHHRA Report. A final BHHRA will be submitted within 30 calendar days after the receipt of EPA's approval of the Amended Draft BHHRA.

5.5.3 Data Evaluation

The BHHRA will be based on all available site data. All historical information on the hazardous substances present in and around the site as provided in the documents referenced in Section 2 of this RI/FS Work Plan will be reviewed. In addition, results of sampling that will be conducted as part of the additional site activities proposed in this RI/FS Work Plan will be included in the data evaluation.

All sampling locations and associated data that will be used for the exposure scenarios to be evaluated in the risk assessment will be identified. The data will be managed in a database

system to facilitate data reduction and development of summary statistics. Information pertaining to data reduction and the selection of chemicals of potential concern (COPCs) is presented in the subsections below.

5.5.4 Guidelines for Data Reduction

The following guidelines for data reduction will be used to produce data summaries for each medium of concern and each potential exposure pathway, for use in developing the BHHRA. These approaches are consistent with RAGS, Volume 1, Human Health Evaluation Manual (Part A) (EPA, 1989) and EPA Region 6 Risk Assessment Guidance (EPA, 1995).

- If a chemical is not positively identified in any sample from a given medium, because it is reported as a nondetect and/or because of blank contamination (as explained below), it will not be addressed for that medium. A chemical will be carried forward into the risk assessment at one-half of the detection limit if a chemical's detection limit is higher than the respective screening value.

- The EPA's exposure point concentration guidance document entitled, "Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites" (OSWER 9285.6-10, December 2002) will be used to determine the appropriate means for deriving confidence limits on the concentrations of chemicals that are below detection in one or more samples from a given medium and sampling location.

- If a chemical is reported in a field sample and in a method blank or field blank, it will be considered as a positive identification if the chemical is present in the field sample at a concentration greater than 10 times (for common laboratory contaminants) or 5 times (for all other substances) the maximum concentration reported in any blank. Common laboratory contaminants include acetone, methylene chloride, methyl ethyl ketone (2-butanone), phthalate esters, and toluene.

- "J" values are estimated concentrations for measurements reported below the minimum confident quantitation limit in a given medium. All data with "J" qualifiers will be assumed to be positive identifications for the chemical in that medium and the corresponding reported concentrations will be used.

- If a chemical is reported as a nondetect in a sample set containing at least one detection, it will be assumed to be present at one-half of the sample quantitation limit for that sample in the calculation of the mean concentration and 95% UCL.

- Duplicate samples from the same sampling location will be considered as one data point in summarizing the frequency of detection and in calculating the 95% UCL. The values reported for the duplicate samples will be averaged and the average concentration will be entered as the concentration for that sampling location. However, the analytical results of all duplicate samples will be used in summarizing the minimum and maximum detected and nondetected concentrations.

- For all sample locations where soils were sampled at multiple depths for a single location, the results from the various depths will be treated as individual data points in summarizing the data.
- In general for risk assessment purposes, the available groundwater data will be reviewed with consideration of sampling methodologies that do not meet the following guidelines:
    - Sampling methodologies should not artificially increase or decrease naturally suspended particle concentrations.
    - Groundwater samples should be collected using a low flow rate.
    - Groundwater samples should generally not be filtered.

5.5.5 Guidelines for Selecting Chemicals of Potential Concern

As part of the selection process for chemicals of potential concern (COPCs), media-specific detection limits are compared with media-specific regulatory screening levels. The purpose of this comparison is to determine whether a given COPC's detection limit is sufficiently low to ensure that at exposure levels below the detection limit (i.e., nondetects only) there will be no non-cancer health hazards or elevated cancer risks in any exposed receptor. Contaminants not excluded by comparison with an appropriate screening level according to the guidelines described below will be evaluated according to the full BHHRA process.

In Appendix I, media-specific detection limits for the VOCs, SVOCs, metals, polychlorinated biphenyls (PCBs), pesticides, and herbicides that might reasonably be anticipated to be present at a site used as an oil refinery or for hazardous waste disposal (both of which apply to the Falcon Site) are compared to EPA Region 6 Human Health Media-Specific Screening Concentrations (MSSLs), TCEQ Tier 1 Protective Concentration Levels (PCLs), and EPA Maximum Contaminant Levels (MCLs) for drinking water.

The following screening criteria will be used to select or eliminate substances as COPCs. These screening criteria are based on EPA guidance (EPA, 1989) as modified by EPA Region 6 (EPA, 1995).

- A chemical will generally be excluded as a COPC within a given medium if it was not detected in any samples from that medium, provided all detection limits are lower than the media-specific screening levels. However, a chemical will be retained for risk assessment if additional information suggests that the chemical may be present at the site.
- A chemical will be excluded as a COPC if it was detected in less than 5% of the samples and was not reported at concentrations exceeding EPA Soil Screening Levels (SSLs) (EPA, 1996a) or federal drinking water maximum contaminant levels (MCLs), provided all the detection limits are lower than these screening levels. At least 20 samples of a particular medium are needed before the frequency-of-detection rule can be applied. Therefore, if less than 20 samples from a given medium are available the chemical will not be excluded as a COPC based on its frequency of detection.

- Arithmetic means will be calculated for site-related and background data based on detected concentrations at each sampling location. Although site-related data for inorganic compounds will be compared with background data, COPCs will not be screened out based on a background comparison. Rather, the BHHRA will evaluate risk based on all COPCs. In addition, the relative contribution of any below-background inorganic compounds to the total risk will be considered separately and discussed further in the uncertainty analysis.
- Inorganic chemicals that are essential human nutrients (e.g., calcium, iron, potassium, magnesium, and sodium) will not be evaluated as COPCs. Those inorganic chemicals that are both essential human nutrients and toxic at higher concentrations (e.g., zinc and selenium, among others) will be evaluated as COPCs.
- If analysis results in tentative identification of a chemical such that it can be classified as a Tentatively Identified Compound (TIC), it will be excluded from the risk assessment if it is not found to be a transformation product of chemicals present at the site and if there is no reason to believe that it is associated with current or historical site activities. If a TIC does not meet these criteria it will be added to the list of chemicals to be evaluated. Only those TICs that are possible degradation products of chemicals associated with site activities, or are potentially associated with site activities, will be evaluated.
- Any reported chemical that is a member of a chemical class of which other members are selected as COPCs will be retained in the risk assessment (e.g., polycyclic aromatic hydrocarbons [PAHs]).

5.5.6 Conceptual Exposure Pathways Assessment

The objectives of the exposure assessment will be to characterize potentially exposed human receptors in the area associated with the former Falcon Refinery, to identify potential exposure pathways, and to establish upper limits on exposure for the most highly exposed receptors. The exposure assessment will incorporate the following key elements.

- Definition of land use.
- Definition of local water use.
- Identification of potential receptors and exposure scenarios.
- Identification of exposure routes.
- Estimation of exposure point concentrations.
- Estimation of daily doses.

As described in Section 5.5.11, the CSM Flowchart (Figure 15) shows the potential human exposure pathways arising from the Site. Development of the CSM's exposure pathways was based on present and anticipated uses of the Site and the nearby land, wetlands, and estuarine/marine features, in addition to other criteria discussed below.

5.5.7 Setting

The Site consists of an approximately 104-acre refinery that operated intermittently and is currently inactive. It is located near Ingleside, Texas in San Patricio County, Texas, at the north and south corners of the intersection of FM 2725 and Bishop Road. When in operation, the refinery had a capacity of 40,000 barrels per day and the primary products consisted of naphtha, jet fuel, kerosene, diesel and fuel oil. Another portion of the site includes a dock facility on Redfish Bay, where materials were transferred between barges and storage tanks. The Site is bordered by wetlands to the east, northeast and southeast, residential areas to the north and southwest, and construction companies to the south and north.

5.5.8 Current and Future Land Use

Land use adjacent to the Site is comprised of predominantly industrial facilities (Figure 6). However, there are residences immediately west (at the intersection of FM 2725 and Bishop Road) and north of the refinery Site along Thayer Road. The Site is bordered by wetlands to the east, northeast, and southeast, residential areas to the north, west, and southwest, Plains Marketing (crude oil storage) to the northwest, and Garrett Construction Company to the south (Figure 6). Since 1986, refinery production activities have not occurred at the Site. Currently, land use at the site is limited to the several ASTs located on the refinery portion of the Site and the docking facility, which is used for crude oil storage and transportation.

The Site is located outside the Ingleside city limits and therefore does not occur within specific zoning areas. San Patricio County does not zone property except as to flood plain status. According to the San Patricio County Surveyor, the Site is located within an industrial area, but is not zoned as industrial or commercial. The county surveyor indicated that if the Site were to be used for residential development in the future, the developer would be required to acquire permits through the county health department. This is the means by which the county is able to control how the property could be used in the future. The county surveyor stated that it would be unlikely that the county would ever allow the Site to be used for anything other than industrial type activity. As such, it is anticipated that that use of the areas bordering the Site will likely remain unchanged in the foreseeable future.

The on-site areas of the Site will be evaluated using industrial and trespasser scenarios. All off-site areas will be evaluated using a residential scenario. Potential recreational uses will be evaluated in the on- and off-site wetlands and the areas adjacent to the current and historical docking facilities.

5.5.9 Surface Water and Groundwater Resources and Uses

Discussion of surface water and groundwater resources associated with the site is provided in the following sections.

5.5.9.1 Surface Water

The site is located in the San Antonio-Nueces Coastal Basin. The Site lies approximately 5 feet above sea level and drains into the on-site wetlands. The topography of the Site is gently sloping to the southeast as revealed by the Port Ingleside, Texas U.S.G.S. topographic map. Surface water drainage from the Site enters the wetlands along the southeastern section of the abandoned refinery. A culvert connects the on-site palustrine/estuarine wetlands to the estuarine wetlands. The wetlands then connect to the Intracoastal Waterway and Redfish Bay. A detailed discussion of Site topography is presented above in Section 2.2.1.4. A discussion of surface water use associated with the in-water segments identified in Section 2.2.1.4 is presented below.

5.5.9.2 Groundwater

Shallow groundwater is detected at depths typically less than eight feet at the adjacent Plains Marketing facility. Additional information indicates that there are two registered shallow (approximately 40 feet bgs) residential water wells located on property east of the Site (on Thayer Road). State of Texas Water Well Reports indicated that the wells are screened in a sand at a depth of 40 to 45 feet below land surface.

During interviews, the EPA and NORCO personnel determined the existence of five domestic water wells in proximity to the Site, on Thayer Road (Figure 7). According to EPA, at least one resident living on Thayer Road uses the groundwater for consumption. It is noted that the resident does not have any information concerning the completion depth of the well or the depth to usable-quality water. Additional data on site-related groundwater will become available upon completion of the additional site investigation activities.

5.5.10 Potentially Exposed Populations

Based on EPA's recommendations and as indicated in Section 5.5.8 above, the on-site areas will be evaluated using industrial and trespasser scenarios; the off-site residential areas will be evaluated using a residential scenario; and potential recreational uses will be evaluated in the on- and off-site wetlands and the areas adjacent to the current and historical docking facilities. Realistic exposure scenarios will be used to assess the health risks to receptors of substances originating from the Site. Residential scenarios will consider families' consumption of produce grown in their home gardens and children's exposure to soil while playing in their yards. If new information suggests other potentially exposed populations, the CSM will be revised accordingly.

5.5.11 Conceptual Site Model

The CSM Flowchart (Figure 15) and CSM Schematic for Human Receptors (Figure 16a) show potential exposure sources, affected media, release mechanisms, routes of migration, and human receptors. The purpose of the CSM is to provide a framework for identifying potential on-site and off-site exposure pathways and to help identify data gaps in the exposure evaluation.

5.5.12 Exposure Pathways

An exposure pathway consists of four elements (EPA, 1989) and includes:

- A source and mechanism of chemical release.
- A retention or transport medium.
- A point of potential human contact with the contaminated medium.
- A route of exposure (inhalation, ingestion, or dermal) at the contact point.

When all of these elements are present, the pathway is considered complete. The assessment of pathways by which human receptors may be exposed to chemicals includes an examination of existing migration pathways (e.g., water or soil) and exposure routes (e.g., inhalation, ingestion, or dermal) as well as those that potentially may occur in the future.

In the CSM Flowchart (Figure 15), primary, secondary and tertiary release mechanisms are identified and potential exposure pathways and exposure routes are delineated for each receptor.

Potential human exposure pathways to be evaluated include but are not limited to: ingestion of and dermal contact with surface and subsurface soil, groundwater, sediment, and surface water and ingestion of biota (e.g., fish and shellfish) exposed via surface water and sediment. In addressing surface water and sediment exposure pathways we will utilize the relevant TCEQ guidance document (TCEQ 2002).

In addition, inhalation pathways associated with soil and groundwater will be evaluated.

5.5.13 Exposure Point Concentrations

For media other than groundwater, the lower of the 95% UCL of the arithmetic mean and the maximum detected value for each COPC will be used to calculate the exposure point concentrations (EPCs) and exposure doses for each medium (e.g., soil and sediment). The 95% UCL will be calculated according to the procedures discussed in the EPA's UCL exposure point concentration guidance document entitled, "Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites" (OSWER 9285.6-10, December 2002).

When determining maximum concentrations and 95% UCLs we will consider the size of the exposure area in accord with TCEQ guidance (TCEQ 2002). For sampling of surface waters and sediments we will ensure that depositional areas are targeted and that receptor exposure pathways are taken into account (TCEQ 2002),

Exposure point concentrations for soil will be developed taking into account potential "hot spots" of contamination. The term "hot spot" is used to describe a localized area where one or more chemicals occurs in concentrations substantially greater than those found elsewhere in a facility zone. The distribution of chemicals on the Site will be reviewed to determine if hot spots

exist. If a hot spot is identified, the hot spot data will be evaluated independently of the data representing the remainder of the zone (i.e., separate exposure concentrations will be calculated for the hot spot and the rest of the zone). This approach will provide prioritization of remedial actions to specific portions of the Site and help define the extent of any necessary remediation.

When using groundwater data for risk assessment purposes, the estimated COPC concentrations must reflect the reasonable maximum concentrations in the aquifer of concern. For this reason, the maximum detected concentration of each COPC in the most recent two years, if such data are available, will be used as the exposure point concentrations.

5.5.14 Exposure Models and Assumptions

This step of the assessment describes the mathematical models that will be used to calculate the dose of each COPC within each applicable exposure route. The mathematical models and exposure parameters that will be used to calculate doses are those recommended by national and regional EPA guidance (EPA, 1989; 1991c; 1995; 1997a). Where appropriate, estimates of dermal and incidental ingestion exposures via surface waters and sediments for recreational use scenarios will rely upon the default values and assumptions described in the relevant TCEQ guidance document (TCEQ 2002).

When feasible, site-specific exposure assumptions based on professional judgment will be incorporated into the exposure models. Chemical-specific equations and values used in estimating doses will be provided in the risk assessment report.

Several types of dose metric will be utilized. The health-effects dose (i.e., the dose metric for evaluating the potential for non-cancer health effects) will be averaged over the actual exposure duration. The cancer-risk dose (i.e., the dose metric for evaluating the potential cancer risk) will be averaged over a 70-year lifetime. The exposure doses will be expressed in units of milligrams of contaminant per kilogram body weight per day (mg/kg-day). Health-effects doses and cancer-risk doses will be calculated under the reasonable maximum exposure (RME) scenario for each potential receptor.

Assumptions concerning the duration and frequency of exposure and the routes of exposure to be evaluated will be based on site-specific information when available and will be documented. In the absence of site-specific information or other guidance, EPA default values will be used.

5.5.15 Toxicity Assessment and Documentation

The toxicity assessment will identify appropriate toxicity values for the COPCs at the site. These toxicity values will be applied to the estimated doses to evaluate cancer risks and potential non-cancer health effects. A recent EPA directive entitled “Human Health Toxicity Values in Superfund Risk Assessments” (EPA, 2003) revises the recommended hierarchy of human health toxicity values originally presented in EPA’s RAGS Part A (EPA, 1989). The Integrated Risk Information System (IRIS) remains in the first tier (Tier I) of the recommended hierarchy as the

generally preferred source of human health toxicity values. IRIS generally contains reference doses (RfDs), reference concentrations (RfCs), cancer slope factors, drinking water unit risk values, and inhalation unit risk values that have gone through a peer review and EPA's consensus review process. IRIS normally represents the official Agency scientific position regarding the toxicity of the reviewed chemicals based on the data available at the time of the review.

The second tier (Tier II) is EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs), which are available at EPA Region 6. Generally, PPRTVs are derived for one of two reasons. First, the Superfund Health Risk Technical Support Center (STSC) is conducting a batch-wise review of the toxicity values in the Health Effects Assessment Summary Tables (HEAST), now a Tier III source. As such reviews are completed, those toxicity values will be removed from HEAST, and any new toxicity value developed in such a review will be a PPRTV and placed in the PPRTV database. Second, Regional Superfund offices may request a PPRTV for contaminants lacking a relevant IRIS value. The STSC uses the same methodologies to derive PPRTVs for both.

The third tier (Tier III) includes other sources of information. Priority will be given to sources that provide toxicity information based on similar methods and procedures to those used for Tier I and Tier II, contain values which are peer reviewed and available to the public, and are transparent about the methods and processes used to develop the values. Consultation with the STSC or headquarters' program office is recommended regarding the use of the Tier III values for Superfund response decisions when the contaminant appears to be a risk driver for the site. In general, draft toxicity assessments are not appropriate for use until they have been through peer review, the peer review comments have been addressed in a revised draft, and the revised draft is publicly available.

Additional sources may be identified for Tier III. Toxicity values that fall within the third tier in the hierarchy include, but need not be limited to, the following sources:

- The California Environmental Protection Agency toxicity values are peer reviewed and address both cancer and non-cancer effects.
- The Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs) are estimates of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure. The ATSDR MRLs are peer reviewed.
- HEAST toxicity values are Tier III values. As noted above, the STSC is conducting a batch-wise review of HEAST toxicity values. The toxicity values remaining in HEAST are considered Tier III values.

If a Tier I or II toxicity value is not available then we will use expert judgement in identifying a suitable value under the broad guidelines for Tier III sources noted above. In accord with EPA's recommendation we will consult with the STSC or headquarters' program office regarding the use of a given Tier III source if the contaminant appears to be a risk driver for the site. If we are

unable to identify an appropriate toxicity value for a given chemical it may not be possible for us to evaluate the potential for health effects or cancer risk with a reasonable degree of confidence. In that case what predictions we can make concerning the chemical's potential health effects or cancer risk will be addressed in our report and discussed qualitatively in the uncertainty analysis. Furthermore, it may be appropriate to use a surrogate toxicity value in the absence of a suitable toxicity value for a given COPC. For example, benzo(a)pyrene is often used as a surrogate for structurally-related polycyclic aromatic hydrocarbons with limited toxicity data.

Cancer slope factors (CSFs) will be identified for those COPCs classified by EPA as carcinogens and RfDs or RfCs will be identified if available. To the extent that reliable subchronic non-cancer toxicity values can be identified they may be used to assess the potential for non-cancer health effects in future on-site industrial workers, on-site/off-site trespassers, and off-site recreational users because the exposure durations for these receptors are expected to be less than 1 year. In the absence of suitable subchronic toxicity values, chronic toxicity values will be employed. Chronic non-cancer toxicity values will be used for the child receptor and other residential receptors.

RfDs and CSFs will be expressed in the BHHRA in the same units as in IRIS, mg/kg-day and $(mg/kg\text{-}day)^{-1}$, respectively. Cancer unit risk factors will be converted to CSFs according to EPA guidance (EPA, 1997b).

In the absence of gastrointestinal absorption adjustment factors for inorganic compounds, a default value of 1 (i.e., no adjustment) will be used (EPA, 2004). It is noted that EPA does not recommend the use of g.i. absorption factors for deriving dermal toxicity factors from oral toxicity factors for organic compounds (EPA, 2004).

5.5.16 Risk Characterization

The objective of the risk characterization is to integrate the information developed in the exposure assessment and the toxicity assessment into an evaluation of the potential current and future health risks associated with the COPCs at the site. The potential for non-cancer health effects will be evaluated for all COPCs. The potential for cancer risk will be evaluated only for those chemicals categorized by EPA as Group A, B, or C carcinogens and for those chemicals that are currently not categorized but for which a cancer slope factor is available. The total potential risks posed by organic and inorganic COPCs will be characterized both with and without inclusion of inorganic compounds not detected above background.

5.5.17 Cancer Risks

Cancer risks are generally expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the carcinogen. Potential excess lifetime cancer risk (ELCR) will be calculated by multiplying the chronic daily intake averaged over 70 years by the exposure route-specific (oral, inhalation, or dermal) cancer slope factor (CSF), as follows:

$$ELCR = CDI * CSF$$

Where:

ELCR = A unitless probability (e.g., 2.0×10^{-5}) of an individual developing cancer
CDI = Chronic daily intake (intake averaged over a 70-year lifetime) (mg/kg-day)
CSF = Chemical- and route-specific cancer slope factor $(mg/kg\text{-}day)^{-1}$

For each exposure scenario, cancer risks will be summed separately over each chemical, each exposure route, and all chemicals and exposure routes.

An ELCR of 1.0×10^{-6} indicates that an individual experiencing the RME estimate has an estimated 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an ELCR because it would be in addition to the risks of cancer individuals face as a result of their genetic make-up or from other environmental causes such as smoking, alcohol consumption, or exposure to ultraviolet radiation from the sun. An excess cancer risk for site-related exposures from 1.0×10^{-4} to 1.0×10^{-6} (equivalent to an extra risk of 1 in 10,000 to 1 in 1,000,000 above the background rate, respectively) is the range that EPA generally considers acceptable. Site-related cancer risks will be reported for all COPCs that pose a risk of 1.0×10^{-6} or greater. For COPCs with cancer risks between 1.0×10^{-4} and 1.0×10^{-6} we will make recommendations pertinent to a risk management decision based on our understanding of the chemical's toxicology and site-specific exposure pathways.

5.5.18 Non-Cancer Health Effects

EPA derives chemical-specific non-cancer toxicity parameters called reference doses (RfDs) and publishes these values online in the IRIS (Integrated Risk Information System) database. According to the online IRIS glossary (accessed 4/29/07), The RfD is "An estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime." The ratio of exposure to toxicity is called the Hazard Quotient (HQ). According to EPA's online National Air Toxics Assessment glossary (accessed (5/8/07), The HQ is the "ratio of the potential exposure to the substance and the level at which no adverse effects are expected. If the Hazard Quotient is calculated to be less than 1, then no adverse health effects are expected as a result of exposure. If the Hazard Quotient is greater than 1, then adverse health effects are possible. The Hazard Quotient cannot be translated to a probability that adverse health effects will occur, and is unlikely to be proportional to risk. It is especially important to note that a Hazard Quotient exceeding 1 does not necessarily mean that adverse effects will occur." The Hazard Index (HI) is generated by summing the HQs for all COPCs that affect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. An HI of less than 1 indicates that, based on the sum of all HQ's from different contaminants and exposure routes, non-cancer health effects from all contaminants are not of concern. An HI greater than 1 indicates that site-related exposures exceed the level deemed protective of the most susceptible subpopulations and that a more sophisticated risk evaluation

(based on toxicologic investigation and site-specific assessment) is warranted unless action is taken to lower the potential for human exposures. The HQ will be calculated as follows:

Non-cancer HQ = CDI / RfD

Where:

HQ = Hazard quotient (unitless)
CDI = Chronic daily intake (averaged over the exposure period) (mg/kg-day)
RfD = Reference dose (mg/kg-day)

As indicated above, the HI will be generated by summing the HQs for all COPCs that affect the same target organ or that act through the same mechanism of action. Separate HIs will be generated for each receptor scenario, exposure route, and chemical, and a total HI will be calculated for all chemicals and exposure routes.

5.5.19 Identification of Limitations / Uncertainty Analysis

The uncertainty analysis will present the major assumptions and uncertainties associated with the risk assessment, including general uncertainties associated with the risk assessment process and site-specific uncertainties associated with the Site. The uncertainty in the evaluation of the probability of health effects and increased cancer risk will be discussed qualitatively. The focus will be on those chemicals and exposure pathways that pose a potential cancer risk of greater than 1 in 1,000,000, or have a total hazard index of greater than one.

5.5.20 Approach for Developing Preliminary Remediation Goals

EPA Region 6 Human Health Medium Specific Screening Levels (MSSLs) or TCEQ Tier 1 Residential PCLs, whichever is more stringent, will be used to define the Preliminary Remediation Goals (PRGs).

The approach for calculating PRGs is discussed in EPA's PRGs directive entitled, "Human Health Evaluation Manual, Part B: Development of Risk-Based Preliminary Remediation Goals" (OSWER Directive 9285.7-01B, December 13, 1991). Part B provides guidance on using U.S. Environmental Protection Agency (EPA) toxicity values and exposure information to derive risk-based PRGs. Initially developed at the scoping phase using readily available information, risk based PRGs generally are modified based on site-specific data gathered during the remedial investigation/feasibility study (RI/FS).
Chemical-specific PRGs are concentration goals for individual chemicals for specific medium and land use combinations at CERCLA sites. There are two general sources of chemical-specific PRGs: (1) concentrations based on ARARs and (2) concentrations based on risk assessment.

The recommended approach for developing remediation goals is to identify PRGs at scoping, modify them as needed at the end of the RI or during the FS based on site-specific information

from the baseline risk assessment, and ultimately select remediation levels in the Record of Decision (ROD).

In general, the equations described in EPA's PRG directive are sufficient for calculating the risk-based PRGs at the scoping stage of the RI/FS. Note, however, that these equations are based on standard default assumptions that may or may not reflect site-specific conditions.

The establishment of PRGs early in the RI process serves as the basis for the RI/FS FSP and QAPP. Detection limits of the proposed analytical methods will be reviewed before the FSP and QAPP are completed to ensure that they are sufficiently low to characterize the Site with respect to both health and ecological risks. To the extent feasible, analytical methods chosen will have detection limits less than human health and ecological risk screening levels.

5.6 Baseline Ecological Risk Assessment

This Baseline Ecological Risk Assessment (BERA) Plan provides an overview of the methods to be used in conducting the ecological risk assessment for the Site. Further information on the Site location and history is presented in Section 2 of this RI/FS Work Plan.

EPA guidance (EPA, 1997) defines ecological risk assessment for the federal Superfund Program as a "qualitative and/or quantitative appraisal of the actual or potential impacts of contaminants from a hazardous waste site on plants and animals other than humans and domesticated species."

The methods that will be used to conduct the former Falcon Refinery Superfund BERA will conform to current EPA guidance including but not limited to EPA 1989b, EPA1992a, EPA 1992b, EPA 1993 and EPA 1997. The BERA process for the site will include the following eight steps (Figure 17) in accordance with the Order:

Step 1 Screening-Level Problem Formulation and Ecological Effects Evaluation.
Step 2 Screening-Level Exposure Estimate and Risk Calculation.
Step 3 Baseline Risk Assessment Problem Formulation.
Step 4 Study Design and Data Quality Objective Process.
Step 5 Field Verification of Sampling Design.
Step 6 Site Investigation.
Step 7 Risk Characterization.
Step 8 Risk Management.

The methods that will be used to conduct site ecological risk assessment include a conservative screening of contaminants against ecotoxicity benchmarks (i.e., screening ecological risk assessment as presented in Steps 1 and 2). The methods also describe site-specific field studies that could be considered as part of a definitive ecological risk assessment if the results of the screening assessment indicate that this is necessary (Steps 3 through 8).

The Screening-Level Ecology Risk Assessment Report will include a discussion of the topography encountered, during the RI sampling effort within the sediment sampling area to allow an understanding of the depositional areas sampled.

5.6.1 Screening-Level Problem Formulation and Ecological Effects Evaluation – Step 1

A screening-level problem formulation and ecological effects evaluation (Figure 17) includes evaluation of site-specific information for determining the nature and extent of contamination and characterizing ecological receptors at the site under investigation. In addition, the screening-level problem formulation includes the development of a Conceptual Site Model (CSM) and the identification of the chemicals of potential ecological concern (COPECs). The CSM developed for ecological receptors addresses the following five issues:

- Environmental setting and contaminants known or suspected to exist at the site.
- Contaminant fate and transport mechanisms.
- Mechanisms of ecotoxicity associated with contaminants and likely categories of affected receptors.
- Complete exposure pathways.
- Selection of endpoints to screen for ecological risk.

The CSM Flowchart for Human & Ecological Receptors (Figure 15) shows potential migration pathways and receptor scenarios to be considered in developing ecological risk evaluations for site contaminants under existing and future conditions. The CSM Schematic for Ecological Receptors (Figure 16b) depicts the general features of these exposure scenarios in a non-technical manner.

5.6.1.1 Data Evaluation

The screening-ERA will use all available site data. All historical information on the hazardous substances present in and around the site as provided in the documents referenced in Section 2 of this RI/FS Work Plan will be reviewed and used where applicable and appropriate. Additionally, results of sampling conducted as part of the additional site activities proposed in this RI/FS Work Plan will be included in the data evaluation.

All sampling locations and the associated data used for the exposure scenario evaluation in the risk assessment will be identified. The data will be managed in a database system to facilitate data reduction and development of summary statistics. Information pertaining to data reduction and the selection of COPECs is presented in the subsections below.

5.6.1.2 Guidelines for Data Reduction

The following guidelines for data reduction will be used to produce the data summaries for each medium of concern and potential exposure pathway for the screening-ERA. These approaches are consistent with RAGS, Volume II, Environmental Evaluation Manual (EPA, 1989), Ecological Risk Assessment Guidance for Superfund (1997), Issuance of Final Guidance: Ecological Risk Assessment and Risk Management Principles for Superfund Sites (1999) and

TCEQ (2001 and 2006) Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas (RG-263).

- If a chemical is not positively identified in any sample from a given medium, because it is reported as a nondetect and/or because of blank contamination (as explained below), it will not be addressed for that medium. A chemical will be carried forward into the risk assessment at ½ of the detection limit if the chemical's detection limit is higher than the respective screening value.

- The EPA's Upper Confidence Limits (UCL) exposure point concentration guidance documents entitled, "Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites" (OSWER 9285.6-10, December 2002) will be referred to in determining the appropriate use of non-detects values in the risk assessments.
- If a chemical is reported in a field sample and a method or field blank, it will be considered a positive identification if the chemical is present in the field sample at a concentration greater than 10 times (for common laboratory contaminants), or 5 times (for all other substances) the maximum concentration reported in any blank. Common laboratory contaminants include acetone, methylene chloride, methyl ethyl ketone (2-butanone), phthalate esters, and toluene.
- "J" values are estimated concentrations reported below the minimum confident quantitation limit. All data with "J" qualifiers will be assumed as positive identifications for that medium and the corresponding reported concentrations used.
- If a chemical is reported as a non-detect in a sample set containing at least one detection, it will be assumed to be present at one-half of the sample quantitation limit for that sample in the calculation of the mean concentration and the 95% UCL concentration of the arithmetic mean.
- Duplicate samples from the same sampling location will be considered as one data point in summarizing the frequency of detection and in calculating the 95% UCL concentrations. The values reported for the duplicate samples will be averaged, and the average concentration will be assumed as the concentration for that sampling location. However, the analytical results of all duplicate samples will be used in summarizing the minimum and maximum detected and non-detected concentrations.
- For all sample locations where soils were sampled at multiple depths for a single location, the results from the various depths will be treated as individual data points in summarizing the data.
- In general for risk assessment purposes, the available groundwater data will be reviewed with consideration of sampling methodologies that do not meet the following guidelines:
    - Sampling methodologies do not artificially increase or decrease naturally suspended particle concentrations.
    - Groundwater samples should be collected using a low flow rate.

- Groundwater samples should generally not be filtered.

5.6.1.3 Guidelines for Selecting Chemicals of Potential Ecological Concern

The following screening criteria will be used to select or eliminate chemicals as COPECs based on EPA guidance (EPA, 1989), as modified by EPA Region 6 (EPA, 1995):

- A chemical will generally be excluded as a COPEC for a medium if it was not detected in any samples from that medium, provided the detection limits are lower than the media-specific screening levels. However, a chemical will be retained for the risk assessment if additional information suggests that the chemical may be present at the site.
- A chemical will be excluded as a COPEC if it was detected in less than 5% of the samples and was not reported at concentrations exceeding screening levels, or above federal drinking water maximum contaminant levels (MCLs), provided all the detection limits are lower than these screening levels. At least 20 samples of a particular medium are needed before the frequency of detection rule can be applied. As a result, frequency of detection will not be applied if less than 20 samples of a given medium are available.
- Arithmetic means will be calculated for the site-related and background data, based on detected concentrations at each sampling location. The data for inorganic compounds will be compared with background data, but only non-bioaccumulative COPECs will be screened out based on a background comparison. In addition, the relative contribution of the inorganic compounds that are not above background to the total risk will be considered separately and discussed further in the uncertainty analysis.

- If a chemical is identified as a tentatively identified compound (TIC), it will be excluded from the risk assessment, if it is not found to be a transformation product of chemicals present at the site, and if there is no reason to believe that it is associated with current or historical site activities. If a TIC does not meet these criteria, it will be added to the list of chemicals to be evaluated. Only those TICs that are possible degradation products of chemicals associated with site activities, or are potentially associated with site activities, will be evaluated.
- Any member of a chemical class that has other members selected as COPECs will be retained in the risk assessment (i.e., polycyclic aromatic hydrocarbons [PAHs]).

5.6.2 Screening-Level Exposure Estimate and Risk Calculation – Step 2

In the initial ecological risk screening assessment, the ecological effects will be evaluated on a preliminary basis and contaminant exposure levels that represent conservative thresholds for adverse ecological effects will be established. The screening ecotoxicity values will represent a No-Observed-Adverse Effect (NOAEL) level for chronic exposure to a sensitive receptor species.

Maximum reported COPEC concentrations will be compared to ecological benchmarks associated with surface water, sediment, and also compared to the respective laboratory quantitation and method detection level. The benchmarks represent conservative ecotoxicity values for invertebrates and plants exposed to COPECs in sediment (freshwater or marine), soil and surface water (freshwater or marine). (Note that waters and sediments will be defined on the amount of total dissolved solids measured (in the over lying water, in the case of sediment) in parts per thousand [‰]: fresh—0.5‰, brackish—0.5-30‰, salt—30-50‰ and brine→50‰.) Peer reviewed ecotoxicity benchmarks will be selected for the screening-level risk comparisons. The selected ecological benchmarks for the site are included in Appendix H (Comparison of Quantitation Limits to Ecological Screening Standards).

COPECs that exceed the selected ecological benchmarks will be retained as COPECs as described in detail by the data reduction method. Bioaccumulative COPECs, including individual and total polycyclic aromatic hydrocarbons, will be retained for further evaluation if they are detected in any site media potentially posing a risk of bioaccumulation to higher trophic levels, even if they are present at concentrations below the screening-level benchmark. (Determination of bioaccumulative COPECs will be based in Table 3-1 of TCEQ's 2001 ERA guidance [as revised in 2006] and/or the methods described within their guidance. Such chemicals are identified in Appendix H herein.) Chemicals without screening levels will be carried forward in the ecological risk assessment, including those chemicals where their quantitation limits exceed their respective screening levels if there is any data indicating that the chemical could be present at the Site. This is because COPECs that bioaccumulate may pose a significant risk to higher trophic level organisms if they biomagnify through the food chain. Selected COPECs will be retained for further evaluation in the BERA. This step of the ecological risk assessment process will conclude with a scientific-management decision point (SMDP). If there are no COPECs retained based on the ecological screening, decision will be made whether the screening-level ecological risk assessment is adequate to assess the potential for risk to ecological receptors and whether the potential risk is acceptable. If a decision of inadequacy or that the potential risk is unacceptable or indeterminable, then the risk assessment process will continue through more detailed assessment steps (Steps 3 through 7).

5.6.2.1 Approach for Developing Ecological Screening Levels

5.6.2.1.1 Soil

Ecological screening levels for soil in the risk assessment will be based on the soil screening levels for target receptor plants and invertebrate communities and will be obtained from the Guidance for Conducting Ecological Risk Assessment at Remediation Sites in Texas [TCEQ] or other sources [e.g., Oak Ridge National Laboratory (ORNL) Risk Assessment Information System (RAIS), Center for Disease Control, National Institute of Health, and EPA].

5.6.2.1.2 Groundwater/ Surface Water

Screening levels for groundwater and surface water will be based on Federal ambient water quality criteria (AWQC) (40 CFR 131.36), or benchmarks that have been developed by TCEQ

(2006) or ORNL (Suter and Tsao, 1996), whichever value is most conservative/protective. For any benchmark from ORNL that is applied in this assessment, only original values will be used. The 20% adjustment factor generally used by ORNL will not be applied. For certain chemicals where insufficient information was available to calculate criteria, the Federal water quality guidance lists lowest-observed-adverse-effect-levels (LOAELs). These values will be extrapolated to no-observable-adverse-effect-levels (NOAELs) by dividing by a factor of 10, and will also be used for screening purposes in those cases where no other benchmarks are available.

For those contaminants detected in the ground water/surface water at the site that have the potential to bioaccumulate (e.g., pesticides and polychlorinated biphenyls [PCBs]), and a pathway is complete, it will be necessary to evaluate the potential for trophic transfer to terrestrial wildlife in developing screening levels for surface water. The potential for evaluating this pathway as part of the screening-level risk assessment will be discussed further with EPA Region 6 and the state and federal trustees.

5.6.2.1.3 Sediments

Screening levels for sediments will be based on the guidelines for freshwater sediments as proposed in the Guidance for Conducting Ecological Risk Assessment at Remediation Sites in Texas (TCEQ 2006, updated), MacDonald et al. (2000), Ontario Ministry of Environment (OMOE) Sediment Guidelines (OMOE, 1993), the Biological Effect Levels developed by the National Oceanic Atmospheric Administration (NOAA) (Long et al., 1995; Long and Morgan, 1990), and the sediment guidelines developed by the Florida Department of Environmental Protection (FDEP, 1994). All of the above referenced databases, including other sources, will be consulted for appropriate values. A hierarchy of values will be established based upon the factors of conservativeness (protectiveness) and the acceptableness of the method(s) cited for the derivation of the value. In terms of sourcing, benchmarks from TCEQ will be considered first, followed by USEPA Region 5 ESL values, MacDonald (2000), etc.

5.6.2.1.4 Screening-Level Ecological Risk Assessment Report

Based on the results of the screening-level exposure estimation and risk calculation, a decision will be made, with the concurrence from the EPA, that either the screening-level ecological risk assessment (Steps 1 and 2) is adequate to determine that ecological threats are negligible, or the process should continue to a more detailed baseline ecological risk assessments (Steps 3 through 8).

Specifically, the three possible conditions with respect to the BERA at this point include:

- There is adequate information to conclude that ecological risks are negligible and therefore no need for remedial action on the basis of ecological risk.
- The information is not adequate to make a decision at this point, and the ecological risk assessment process will continue (Steps 3 through 8).

- The information indicates a potential for adverse ecological effects, and a more through assessment is warranted.

A Draft Screening-Level Ecological Risk Assessment (SLERA) Report that documents the decision and its basis will be prepared and submitted to EPA for review and approval according to the project schedule in the Final RI/FS Work Plan. The Amended Draft SLERA will be prepared and submitted within 45 calendar days of receipt of the EPA's comments. A Final SLERA will be submitted within 30 days of the EPA's approval of the Amended Draft SLERA.

5.6.3 Baseline Ecological Risk Assessment

If the SLERA Report indicates a need for further ecological risk evaluation, a BERA will be required.

The basic components of the BERA (Figure 17) include:

- Problem Formulation (Step 3)
- Characterization of Exposure (Step 3)
- Characterization of Ecological Effects (Step 3)
- Risk Characterization (Step 7)

Additional components of the BERA design to completely develop and substantiate the results of the basic BERA components identified above include:

- Study Design and Data Quality Objective Process (Step 4).
- Field Verification of Sampling Design (Step 5).
- Site Investigation and Analysis Phase (Step 6)

Each of these components is discussed in more detail in the following sections.

The principal guidance documents that will be used in conducting the BERA include, but are not limited to:

- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (EPA, 1997)
- Role of Ecological Baseline Risk Assessments (EPA, 1994a)
- Supplemental Region 6 Risk Assessment Guidance (EPA Region 6, 1995)
- Framework for Ecological Risk Assessment (EPA, 1992a)
- Evaluation of Terrestrial Indicators for Use in Ecological Assessments at Hazardous Waste Sites (EPA, 1992b)

- Guidance for Data Usability in Risk Assessment (EPA, 1992c, 1992d)
- Risk Assessment Guidance for Superfund, Vol.2 - Environmental Evaluation Manual (EPA, 1989a)
- Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference (EPA, 1989b)

5.6.3.1 Baseline Risk Assessment Problem Formulation – Step 3

Problem formulation is the first step of the BERA process and establishes the goals, breadth, and focus of the assessment (EPA, 1992a). This step will refine the screening–level problem formulation and expand on the ecological issues that are of concern at the site. It provides an evaluation of the data (including an assessment of data usability), contaminants of potential concern, habitats, receptors, exposure pathways, ecotoxicity, and selection of endpoints for further study (EPA, 1991). For both a screening-level ecological risk assessment and a definitive ecological risk assessment, the product of the problem formulation is a site conceptual model, which identifies the potential chemical transport pathways, receptors, and the areas of primary concern to be addressed in the ecological risk assessment. Following is a description of the components that will be conducted as part of the problem formulation.

At the conclusion of the BERA problem formulation, a Draft BERA Problem Formulation (PF) Report will be prepared and submitted to EPA for review and approval according to the schedule identified in the Final RI/FS Work Plan. An Amended Draft BERA PF Report will be prepared and submitted to EPA within 30 calendar days of the receipt of their comments related to the Draft BERA PF Report. A Final BERA PF Report will be prepared and submitted to EPA within 14 calendar days of receipt of their comments related to the Amended Draft BERA PF Report. The BERA PF Report will discuss the assessment endpoints, exposure pathways, risk questions and the CSM integrating these components. The information presented in the BERA PF Report will be used to select measurement endpoints and to develop the BERA Work Plan and SAP for the site.

5.6.3.1.1 Refinement and Further Characterization of COPECs

As the first task of this step in the BERA problem formulation process, the information used and developed during the screening-level assessment will be reassessed along with any additional site- specific information to refine the scope and goals of the BERA. This process will follow default procedures with the exception that site specific information will be utilized in place of any conservative assumptions used during the screening-level phase.

5.6.3.1.2. Characterization of Habitats

Characterization of potential habitat at the site is another component of the problem formulation, and is briefly presented in this plan to provide some ecological background on the site. Additional information on the ecological setting including terrestrial habitat and vegetation will

be obtained through a site-specific ecological survey to be conducted prior to completing the BERA Report.

5.6.3.1.3 Ecological Site Survey

A detailed description of current terrestrial and aquatic habitat including vegetative cover at the site and surrounding area is not available at this time. A field visit to the site by agency personnel and a qualified field biologist will be conducted prior to starting the risk assessment report. The field visit will allow interested parties to gain a consensus on the types of habitat that are available to ecological receptors at and in the vicinity of the site. Information from this site ecological survey will be included as the first step of the ecological risk assessment report.

5.6.3.1.4 Identification of Ecological Receptors

Identification of the ecological receptors at or in the general vicinity of the site is another component of the problem formulation and is presented in this work plan to provide some ecological background on the site. Selection of potential target receptors that are likely to occur at or in the general vicinity of the site will be completed as part of the problem formulation after conducting a site ecological survey. An attempt will be made during the survey to identify the presence of individual species of mammals, birds, fish, amphibians, and reptiles and their habitats.

A threatened and endangered (T&E) species search using available literature and local non-profit research methods will be conducted as part of the ecological risk assessment to identify the potential for species to occur at or in the vicinity of the site. The site ecological survey will also be used to identify site-specific habitat and the likelihood of species of special status to nest or forage in habitat at or in the vicinity of the site. If the potential for a threatened or endangered species to routinely utilize the site is identified, then the species will be selected as a target receptor. Potential for risk to that species will be evaluated. However, possible occurrence as a T&E species does not confirm that a species is present nor does it preclude other T&E species that are not listed from utilizing habitats within the vicinity of the site.
An endangered species is a native species whose prospect of survival or recruitment within the state is in imminent jeopardy. This determination is based primarily upon the species status in Texas. A threatened species is a native species that, although not presently in danger of extirpation, is likely to become endangered in the foreseeable future in the absence of special protection and management efforts. A special concern species may be one of the following:

Category I—a native species with a presently stable or increasing population that current evidence indicates is especially vulnerable to extirpation because of limited range, low population or other factors.

Category II—a native species identified by technical experts as possibly threatened or vulnerable to extirpation but for which little, if any, evidence exists to document the population level, range or other factors pertinent to its status.

The San Patricio County Texas currently has 29 animal species and no plant species that are listed as endangered or threatened under either federal or state guidelines (Table 1 – Listed and Endangered and Threatened Species).

5.6.3.1.5 Identification of Exposure Pathways

An exposure pathway describes the course a chemical takes from its source to an ecological receptor. An exposure pathway generally consists of 4 elements: 1) a source and mechanism of chemical release, 2) a retention or transport medium, 3) a point of contact with the receptor, and 4) an exposure route (e.g., ingestion) at the point of contact.
Exposure pathways for specific ecological receptors at the site will be identified by medium (i.e., soil, groundwater, surface water, sediment), and discussed in relation to the chemical fate and transport properties of the COPEC. The general taxonomic groups (i.e, mammals, birds, vegetation) potentially at risk from exposure to chemical contamination at the site and the associated exposure pathways have been summarized in a preliminary CSM (Figures 15 and 16b). This preliminary CSM will be refined after data from the site ecological survey has been compiled and will include species-specific target receptors and identification of significant, insignificant, and incomplete exposure pathways.

5.6.3.1.6 Ecotoxicity of Contaminants

Toxicity information will be compiled for the COPECs selected, and presented in a tabular form by receptor group (e.g., birds, mammals, aquatic organisms). For birds and mammals, there will be a brief description of target organs and any other relevant characteristics of toxicity of each chemical. This information will be compiled from a number sources including the RAIS, ATSDR toxicological profiles, the Handbook of Toxic and Hazardous Chemicals and Carcinogens (Sittig, 1985), and the Hazardous Substances Database (HSBD). The most sensitive test mammalian and avian receptors will be listed for each of the COPECs based on a review of the scientific data, and will be represented by those species in which effects were observed at the lowest levels of exposure. In selecting the most sensitive species, oral studies will be used, and preference will be given to feeding and drinking water studies.
Federal and State AWQC will be used to evaluate toxic effects of COPECs of fish and other aquatic species in surface water and the palustrine/estuarine wetlands and Redfish Bay. While AWQC are assumed to be protective of fish and aquatic invertebrates from a surface water standpoint, they do not take into account ingestion of contaminated sediments. The "*sediment to invertebrate*" and "*sediment to fish*" pathways will be addressed in the ecological risk assessment. This evaluation shall also consider population effects as well as possible risks to vertebrates that consume fish and invertebrates exposed to sediment COPECs. Sediment quality criteria and benchmarks for the assessment of toxicological effects on sediment-associated biota will be used to evaluate toxic effects of COPECs on benthic organisms.

Media-specific screening benchmarks for amphibians, reptiles, and plants (receptors to soil) developed by ORNL (Efroymson *et al.* 1997a & 1997b, Jones 1997, Sample *et al.* 1996, 1998, Suter and Tsao 1996) from the RAIS will be used to assess impacts on these receptor groups. It

is recognized that media-specific benchmarks are essential for a rigorous assessment. In some cases, ecotoxicity values may be lacking or may be available for some but not all media and/or receptors. Such circumstances increase the uncertainty associated with the assessment, which will be addressed in an appropriate discussion. In some cases, it may be possible to extrapolate using surrogate chemical data following methods such as those outlined in TCEQ 2001 (§3.5.2).

5.6.3.1.7 Selection of Assessment and Measurement Endpoints, and Testable Hypotheses

Given the potential for ecological impacts to occur at the site, a set of assessment endpoints will be proposed for the purposes of achieving the goals of the environmental assessment. The assessment endpoints represent potentially significant ecological impacts. For each of the designated assessment endpoints, one or more measurement endpoints will be selected based on their ability to integrate modeled, field, or laboratory data with the individual assessment endpoint. For each of the assessment endpoints, testable hypotheses will be identified. The hypotheses provide the structure for evaluation of the results in the analysis phase of the assessment (EPA, 1992a).

Assessment endpoints are explicit expressions of the environmental value that is to be protected (EPA, 1992a). Several criteria that will be considered in selecting assessment endpoints are (Suter, 1989; 1990; 1993):

- Biological relevance.
- Susceptibility to exposure and sensitivity to toxicity.
- Societal relevance.
- Unambiguous operational definition (without this criteria, endpoints provide no direction for testing and modeling, and the results of an assessment tend to be ambiguous)
- Capability of measurement.

Available toxicological information will also be considered in the selection of assessment endpoints. Because the habitats and receptors at a site are unique, there is no standard list of assessment endpoints. Population abundance, community structure, or ecosystem productivity are typically evaluated. Knowing what the valuable ecological receptors are in the vicinity of the site provides a basis for selecting both the assessment and measurement endpoints.

Measurement endpoints are the measurable environmental characteristics that are predictive of the selected assessment endpoint. Measurement endpoints approximate or predict conditions at a site (Maughan, 1993) and link the conditions to the assessment endpoint. The criteria that will be considered in the selection of measurement endpoints include:

- Readily measured or evaluated.
- Corresponds to or is predictive of an assessment endpoint.
- Appropriate to the scale of the site, exposure pathways, and temporal dynamics.

- Low natural variability.
- Rapidly responding and sensitive to receptors.

For the evaluation proposed at the site, evaluation of appropriate measurement endpoints will involve the use of benchmark and literature toxicity values that satisfy many of the listed criteria. Several scenarios will be used to evaluate each impacted media at the site to ensure that potential impacts of contaminants from each media are thoroughly evaluated for each possible receptor group.

5.6.3.1.8 Conceptual Site Model

The primary objective of the problem formulation is the development of a working CSM, which serves to define how contamination might affect ecosystems at the site (Norton et al., 1992). Information provided by the ecological setting characterization, selection of preliminary COPECs, target receptors, exposure pathways, ecotoxicity, and endpoints can be integrated into a model that describes how individual components of the ecosystem may interact with each other and with site-related contamination. The preliminary CSM completed as part of the screening-level problem formation will be refined to include species-specific target receptors and identification of significant, insignificant, and incomplete pathways of exposure. Working hypotheses as well as questions for the additional site investigation to address will be identified in conjunction with refinement of the CSM.

5.6.3.2 Characterization of Exposure

The exposure characterization will identify the potential magnitude and frequency by, which target receptors are exposed to COPECs that have migrated through various pathways to terrestrial and aquatic habitats. In addition, the exposure characterization will identify all routes of exposure by which species inhabiting those areas may be exposed, and serves as input to the characterization of risk. The specific objectives of the characterization of exposure will be to:

- Select target receptors or communities that directly relate to assessment endpoints.
- Identify significant pathways/routes by which target receptors are potentially exposed.
- Predict exposure doses for selected target receptors.

5.6.3.2.1 Selection of Target Receptors and Communities and Routes of Exposure

Target receptors and communities will first be selected for evaluation in the screening ecological risk assessment. The selection of target receptors and communities will be based on the concept that it is neither feasible nor cost effective to measure contaminant effects on all species inhabiting terrestrial and aquatic systems. In addition, these systems are complex and ecological theory has not identified “aggregate” or “holistic” measures of system “health” or defined generic properties that are indicative of overall system status or integrity. Exposure pathways will be selected for each of the target receptors based on the assessment of the habitat types and

the patterns of chemical contamination and sensitivity. Emphasis will be given to those receptors or communities that have the greatest potential for exposure. Individual target receptors will only be selected for birds and mammals. Fish, benthic organisms, amphibians, reptiles, and plants will be evaluated as communities. When selecting communities for evaluation, receptor communities that are present in freshwater and marine systems will be evaluated separately.

All incomplete exposure pathways will be eliminated from consideration. For an exposure pathway to be complete, a contaminant must be able to travel from the source to the ecological receptor and to be taken up by the receptors via one or more exposure routes (TCEQ, 2001 and 2006). For terrestrial animals, there are three basic exposure routes: ingestion, inhalation, and dermal contact or absorption. Little information is available for quantifying the inhalation or dermal absorption exposure pathways for most wildlife. Although these exposure pathways may be complete, their risk is considered minimal when compared to dietary and incidental ingestion (TCEQ 2001 and 2006).

A list of species inhabiting or potentially inhabiting the site and areas adjacent to the site will be summarized in the risk assessment report. From this list of potential ecological receptors, habitat-specific target receptors will be chosen based on consideration of the following species-specific criteria:

- Species that potentially occur within the habitat to be evaluated.
- Species that represent a range of feeding relationships within each habitat.
- Species that are likely to be maximally exposed.
- Species that are critical to the structure and function of the particular ecosystem they inhabit.
- Species that are sensitive to the COPECs.
- Species that have a realistic and significant potential for exposure.
- Species for which sufficient exposure and toxicity data are available for evaluation.
- Species that are not threatened but similar to threatened or endangered species, and are of local concern.
    - Species will be phylogenetically related as closely as possible,
    - Species will be similar in habitat and diet as threatened or endangered species, and
    - Species will be as or more sensitive than threatened or endangered species, if at all possible

In addressing the sensitivity of species to the COPECs, it is important to note that for the screening-level risk assessment the toxicity data that will be used will be based on the most conservative values in the literature for the category of species (e.g., birds, small mammals) being evaluated. It is expected that the most sensitive species in the literature will typically be a function of the most frequently used experimental or test species. Thus, due to the limitations of the toxicity literature, the most conservative toxicity values for each chemical will be compared to the exposures for those species within the same phylogenetic class whose exposure is expected to be greatest at the site.

It is also important to note that even though target receptors will be selected for evaluation in the screening-level risk assessment, these species also represent the exposure that other similar species with comparable feeding habits may be receiving, and thus, serve as surrogate receptors.

Factors that will be considered in the exposure pathway selection include:

- Local topography.
- Local land use.
- Surrounding terrestrial habitat.
- Surrounding aquatic/wetland habitat.
- Availability of media-specific and location-specific data.
- Prediction of contaminant migration.
- Chemical characteristics of COPECs, including persistence and mobility.

These factors affect the selection of exposure pathways, since they determine the types and locations of ecological receptors and COPECs in the environment. The topography, land use, terrestrial habitat, and aquatic/wetland habitat in the site affect the type and locations of ecological receptors there. In addition, the characteristics of the COPECs and their potential for migration and uptake affect which media or tissues COPECs might be expected in, and thus would also affect exposure pathway selection.

5.6.3.2.2 Exposure Point Concentrations

Once the potential exposure pathways and affected habitats have been defined and the potential target receptors identified, points of likely exposure will be described. The chemical concentrations at these contact points (i.e., exposure point concentrations) are critical in determining exposure intake and subsequent risk to receptors. Exposure point concentrations may be developed for specific areas within the site or on a site-wide basis depending on the different terrestrial habitat available. This approach should facilitate prioritization of risk management decisions to specific portions of the site where ecological receptors may be more likely to occur. This would also help define the extent of any necessary ecological risk-based remediation.

Exposure point concentrations will be developed for the soil, taking into account potential ‘hot spots’ of contamination as well as availability of appropriate habitat. The hot spot evaluation shall also consider the magnitude of the chemical concentration as well as the habitat needs and home range of the receptor in question. In addition, area-specific or site-wide exposure point concentrations may be calculated based on the availability of terrestrial receptor habitat. The term “hot spot” describes a localized area where one or more chemicals occur in concentrations substantially (e.g., 2 or more orders of magnitude) greater than those found elsewhere at the site. The identification of hot spots will be determined on a case-by-case basis after thorough evaluation of both current and historical sampling data.

Potential impacts to ecological receptors will be assessed in the screening-level ecological risk assessment by first determining the availability of appropriate terrestrial habitat. Depending on the breakdown of appropriate habitat, two exposure point concentrations will be calculated; the maximum detected concentration and the 95% UCL concentration of the mean. If the 95% UCL concentration exceeds the maximum detected concentration for a chemical for a particular habitat area, the maximum detected concentration will be used as the exposure point concentration for that area. For those organisms that are stationary or are not very mobile (e.g., plants, soil invertebrates), the maximum detected concentration is generally applicable as the exposure point concentration. The 95% UCL concentration is most applicable to those organisms that are mobile and may be exposed to a larger portion of the site.

For those species with home ranges in excess of the site area, it would be plausible to evaluate aggregate risk of exposure based on a ratio of useable habitat area in their home range to useable habitat area within the site. An aggregate exposure point concentration would be calculated (i.e., 95% UCL) for species with extensive home ranges provided that COPEC distributions are fairly uniform within each of the site habitat areas, and that contamination, or lack of contamination, within the remainder of the species' home range is identified (i.e., ambient levels).
Exposure point concentrations will be developed for surface water and sediment in the site palustrine/estuarine wetlands and Redfish Bay.

Potential impacts to ecological receptors in the wetlands and bay will be evaluated in the ecological risk assessment using two exposure point concentrations for each wetland habitat type; the maximum detected and the 95% UCL concentrations. The maximum concentration is most applicable to those aquatic organisms that are not mobile (e.g., benthic macroinvertebrates) and may be exposed to a localized area. The 95% UCL is most applicable to those organisms that are mobile (e.g., fish, amphibians) and may be exposed to a larger portion of the wetlands and bay areas. If the 95% UCL concentration exceeds the maximum detected concentration for any chemical, only the maximum detected concentration will be used as the exposure point concentration.

Exposure point concentrations will be developed for on-site groundwater directly beneath the Site and for off-site groundwater down gradient of the Site.

If groundwater occurs at depths of less than 2 to 10 feet, potential impacts to plant target receptors from exposure to on-site groundwater will be evaluated using two exposure point concentrations; the maximum detected and the 95% UCL concentrations. If the 95% UCL concentration exceeds the maximum detected concentration for any chemical, only the maximum detected concentration will be used as the exposure point concentration.

With the exception of shallow groundwater that may provide a source to terrestrial vegetation, the groundwater is an incomplete ecological pathway unless there is a groundwater discharge to sediment and/or surface water. Potential impacts to aquatic receptors from off-site groundwater downgradient of the Site discharging to surface water will be also be conservatively evaluated

based on a completed groundwater to surface water pathway. It is assumed that aquatic receptors in Redfish bay may potentially be impacted by impacted groundwater, if the contaminant plume emanates into the bay. It is assumed that direction of groundwater flow is to the northeast from the Site towards and into the wetland areas and Redfish Bay. If the groundwater to surface water pathway is complete, two exposure point concentrations will be used to assess groundwater; the maximum detected and the 95% UCL. Again, if the 95% UCL concentration exceeds the maximum detected concentration for any chemical, only the maximum detected concentration will be used as the exposure point concentration. This exposure point concentration will be used to evaluate the total contribution of groundwater COPECs to the surface water taking into account the dilution of groundwater when it discharges to surface water.

In the case of groundwater contributing contaminants to sediment, this depends upon the existence of a plume and the COPECs involved and their chemistry and the media's chemistry (organic carbon, etc.) at the interface. In the screening assessment, groundwater concentrations will be evaluated as discussed previously, as will sediment concentrations. Should additional pore water data be required, then an additional sampling effort will be required to provide such data to evaluate the potential loading in the area of the release.

It is anticipated that many of the selected target receptors will be exposed through dietary intake (e.g., seeds, earthworms, fish, mammals). Since measured exposure point concentration data will not be available for dietary items, they will be predicted using uptake models. For example, an important exposure pathway for herbivorous terrestrial animals is the consumption of forage. The chemical concentrations in plants will be estimated by multiplying soil concentrations with chemical-specific plant uptake factors as available in the literature. Similar uptake models can be used to estimate chemical concentrations in other tissue types (e.g., earthworms, fish, mammals), and will be dependent on the target receptors selected for evaluation in the risk assessment.

5.6.3.2.3 Estimation of Exposure Doses

Once exposure point concentrations have been determined, daily exposure for target receptors will be estimated using conservative exposure parameters for each receptor. For target receptors or communities that are exposed directly to the media in which they live (e.g., aquatic organisms, plants), exposure will be expressed in terms of measured concentrations of contaminants in the media (e.g., water). For organisms exposed via the ingestion pathway, exposure dose models will be developed which express exposure in terms of contaminant intake per kilogram of body weight per day (mg/kg-day). These models will incorporate information on exposure frequency, exposure point concentrations, body weights, and ingestion rates.

To predict exposure to a chemical by a target receptor, exposure needs to be evaluated through each complete exposure pathway. The exposure algorithm for estimating daily intake through the ingestion exposure route can be generically described as:

$$EDI = C_{medium} \times IR \times FI$$

Where:

EDI = Estimated daily intake to a chemical through an exposure route (mg/kg-day).
C_{medium} = Concentration of contaminant in a particular medium (mg/kg or mg/L).
IR = Ingestion rate of medium by receptor, normalized for body weight (mg/kg BW-day or L/kg BW-day).
FI = Fraction ingested from contaminated source (unitless).

Total exposure of a target receptor from ingesting contaminated food, soil, sediment, and water can be generically described as:

$$EDI_{total} = EDI_{soil} + EDI_{sediment} + EDI_{water} + EDI_{food}$$

Where:

EDI_{total} = Total exposure dose (mg/kg-day).
EDI_{soil} = Estimated daily intake of contaminant via soil (mg/kg-day).
$EDI_{sediment}$ = Estimated daily intake of contaminant via sediment (mg/kg-day).
EDI_{water} = Estimated daily intake of contaminant via water (mg/kg-day).
EDI_{food} = Estimated daily intake of contaminant via food, either forage or prey (mg/kg-day).

While dermal contact and inhalation are possible contaminant uptake routes, little information is available for quantifying these exposure pathways for wildlife when compared to the availability of information for quantifying ingestion (TNRCC, 1996). Assumptions for each of the required exposure parameters will be based on literature as well as site-specific information. Exposure parameters that will be needed as part of the quantification of ingestion are as follows:

- Area use factor (unitless percent)
- Migration factor (unitless percent)
- Bioavailability (unitless percent)
- Most sensitive life stage
- Body weight and ingestion rates
- Fraction of contaminated dietary component (unitless percent)

5.6.3.3 Characterization of Ecological Effects

In the ecological effects characterization, information on the toxicity of the COPECs to ecological species will be presented. Toxicity information will be used to develop toxicity reference values (TRVs) for selected target receptors or communities. TRVs represent NOAELs as doses or media concentrations. For some chemicals, the TRVs are true NOAELs and for other chemicals, TRVs are developed as NOAELs using available toxicity information and extrapolation factors.

5.6.3.3.1 Literature Review of Toxicity Data

The toxicity of each COPEC will be assessed for aquatic life, terrestrial wildlife, amphibian and reptilian wildlife, and vegetation, where relevant. Scientific literature and regulatory guidelines will be reviewed for media-specific and species-specific toxicity data. Sources of criteria and toxicity data for the ecological assessment include the following:

- Federal/State Regulations and Guidance
- AWQC
- AQUIRE database
- SETAC Database for Aquatic Organisms: Tissue Residues
- PHYTOTOX database
- TERRETOX database
- ENVIROFATE database
- HSDB
- ORNL RAIS
- Registry of Toxic Effects of Chemical Substances (RTECs)
- IRIS - (non gavage studies)
- U.S. Fish and Wildlife Service Technical Reports (Eisler)

If necessary, toxicity information will also be obtained from a variety of peer-reviewed primary literature sources.

5.6.3.3.2 Derivation of Reference Toxicity Values

For most constituents, several sources will be reviewed to derive TRVs. Studies obtained from these sources provide exposure data associated with a variety of toxicity endpoints (i.e, LOAEL, NOAEL, median lethal dose (LD_{50})) and effects (i.e., neurotoxicity, developmental toxicity, death). The toxicity values used in the assessment will be those that exhibit the lowest exposure doses reported to be toxic or the highest doses associated with no adverse effects. The process of selecting an appropriate toxicity endpoint for use in the TRV derivation requires guidelines for determining the appropriateness of specific endpoints. In general, effects that have apparent ecological implications will be preferentially used. Thus, preference will be given to endpoints such as reproductive effects (e.g., decreased fertility, teratogenicity, developmental effects and fetal re-absorption) and mortality of adults or offspring, both of which would impact the species population. Preference will also be given to serious histopathological effects (necrosis or other damage to target organs tissues: liver, kidney, brain/central nervous system, lungs, stomach, pancreas, etc.) that would impact primary body functions. In the absence of these preferred data, consideration will also be given to effects such as alteration in biochemical functions of organs that could be correlated with decreased survivability (e.g., acetylcholinesterase function), as well as alteration in normal behavior that may result in decreased survivability of a receptor (e.g.,

impaired motor skills, increased reaction time, altered feeding habits). Other types of effects data such as increased body weight, decreased liver size, increased blood lead, which are not readily associated with decreased survivability or longevity, will only be used in the absence of preferred toxicity data.

In addition, care will be taken in those cases involving threatened and endangered species to find NOAEL's that afford additional protection, and if possible documented protection, otherwise appropriate safety factors will be applied to achieve said protection (see below).

Carcinogenicity endpoints are not considered appropriate for derivation of TRVs, since a number of factors confound the extrapolation of carcinogenicity data between species of the same phylogenetic class. These factors include:

- The no-threshold assumption for carcinogens precludes the extrapolation of a TRV to a chronic no-observable effect level.
- Carcinogenic studies with laboratory animals often require high doses to generate tumors within the lifetime of the study and/or test species. The latency period for tumor induction is potentially greater than the lifetime of the ecological receptor of concern due to lower levels of exposure an organism would receive in the field.
- The inbred origins of many laboratory animals do not necessarily reflect the outbred species that would be expected to occupy the site. Within a given species there are also significant differences between individuals in their abilities to bioactivate and deactivate carcinogenic molecules. Factors such as age, sex, genetic makeup, and nutritional disposition contribute to uncertainty (Travis, 1988).

In deriving TRVs, data for chronic toxicity will be preferentially used, when available. The resulting TRV will thus protect for chronic effects. Chronic exposure has been defined by Suter et al. (1983) as an extended exposure of an organism to a chemical, which is conventionally taken to include at least a tenth of the life span of the species. Although chronic studies, as defined here, will be preferentially used in the assessment, some studies may fall into a subchronic category, in which the length of the study extends less than a tenth of the lifespan, but longer than what would be considered an acute exposure. Acute exposure is defined in this assessment as a brief exposure to a chemical, which refers to an instantaneous exposure (e.g., oral gavage) or continuous exposures of minutes to a few days (Suter, 1993). In the absence of chronic and subchronic data, TRVs will be derived based on available acute or sub-chronic data (as available), and extrapolated to a chronic no effect level.

A number of extrapolation factors will be used to develop TRVs for test species that are protective of target receptors at the site. Where only acute lethal toxicity values are available, TRVs will be derived by dividing acute toxicity values by an appropriate extrapolation factor. As recommended by EPA Region 6, a median lethal dose (LD_{50}) will be extrapolated to a chronic LOAEL by dividing the LD_{50} by a factor of 10. Lewis et al. (1990) determined chemical-specific ratios between LD_{50} values and NOAELs for the same species in a total of 490 studies. The results of the evaluation by Lewis et al. indicated that a factor of 6 was adequate to protect 99.9

percent of the populations for 85 percent of all evaluated chemicals. Thus, dividing an LD_{50} by a factor of ten to extrapolate to a chronic LOAEL should be adequately protective.

EPA recommends a factor of 10 when extrapolating from a chronic LOAEL to a chronic NOAEL (EPA, 1997). Weil and McCollister (1963) evaluated ratios of LOAELs to NOAELs from both subchronic and chronic studies for laboratory animals (Lewis et al. 1990). Approximately 96% of the studies (50 of 52) resulted in ratios of less than or equal to 5. Thus, a factor of 10 is adequately protective in extrapolating from a chronic or sub-chronic LOAEL to a chronic NOAEL.

Toxicity data for aquatic organisms, amphibians and reptiles, and plants are typically expressed in terms of media concentrations (e.g., AWQC, sediment and soil concentrations) rather than as a dose. These values will be directly compared to site-specific media concentrations, with no application of extrapolation factors, except if species-specific aquatic TRVs need to be derived. In this specific case, extrapolation factors have been proposed by Suter et al. (1983) and Mayer et al. (1986), and will be used in this assessment. LOAELs will be extrapolated to NOAELs by dividing by 10, as indicated below. For ecotoxicity values used in this assessment that were obtained from ORNL databases, only original values will be used. The 20% adjustment factor typically used by ORNL will not be applied.

Therefore, the safety factors include:

- Acute to Chronic LOAEL: divide by 10.
- Sub-chronic LOAEL to Chronic NOAEL: divide by 10.
- Chronic LOAEL to Chronic NOAEL: divide by 10.
- If the test organism is within the same class and order the factor of 10 will be decreased to a factor of 5.
- If a chain of safety factors are used, they will be multiplied together first, and then the starting end point divided by the resultant to achieve the necessary TRV.

5.6.4 Study Design and Data Quality Objective Process – Step 4

The study design and DQO process step of the BERA will establish the measurement endpoints, which complete refinement of the CSM in Step 3. The CSM will then be used to develop the study design and DQOs. The BERA Work Plan and the SAP, which will describe the details of the site investigation as well as the data analysis methods and the DQOs. The BERA Work Plan will describe the assessment endpoints, exposure pathways, questions and testable hypotheses, measurement endpoints and their relation to assessment endpoints, and uncertainties and assumptions. The SAP will describe data needs; scientifically valid and sufficient study design and data analysis procedures; study methodology and protocols, including sampling techniques' data reduction and interpretation techniques, including statistical analyses' and quality assurance procedures and quality control techniques.

A Draft BERA Work Plan and a Draft SAP will be developed and submitted to EPA for review and approval according to the schedule specified in the Final RI/FS Work Plan. An Amended Draft BERA Work Plan and an Amended Draft SAP will be submitted to EPA within 30

calendar days of the receipt of their comments related to the associated draft documents. The Final BERA Work Plan and the Final SAP will be submitted to EPA within 14 calendar days of the receipt of their comments related to the associated amended draft documents.

5.6.5 Field Verification of Sampling Design – Step 5

The field verification of sampling design step of the BERA process will ensure that the DQOs for the site can be met. During this step, the site appropriateness and implementability of the selected assessment endpoints, testable hypotheses, exposure pathway model, measurement endpoints, and study design from Steps 3 and 4 will be verified. This step will be completed as part of finalizing the BERA Work Plan and SAP. The Final BERA Work Plan and Final SAP must be approved by EPA prior to implementation the site investigation and analysis phase (Step 6).

5.6.6 Site Investigation – Step 6

During this step, site investigation and analysis activities will be implemented as detailed in and in accordance with the BERA Work Plan and the SAP. The results of the site investigation and analysis will be utilized to characterize the ecological risks (Step 7).

The Final BERA Work Plan for the site investigation activities will be based on the CSM and will specify the assessment endpoints, risk questions, and testable hypotheses. All DQOs and requirements for co-located samples will be adhered to in accordance with the BERA Work Plan during the site investigation.

During the analysis phase of the BERA process, all data will be technically evaluated on the existing and potential exposures and ecological effects at the site. The analysis will be based on the information collected during Steps 1 through 5 and will include additional assumptions or model to interpret the data in the context of the CSM. The SAP will be revised as required by changes in field conditions and/or new information on the nature and extent of contamination at the site.

5.6.7 Risk Characterization – Step 7

The risk characterization will be the final phase of the BERA process and will include risk estimation and description. The risk characterization will integrate information from the problem formulation and the exposure and ecological effects characterizations to estimate the nature and extent of ecological risk or threat, and the environmental impact from site activities. The ecological risk characterization will be based on a weight-of-evidence approach, where multiple lines of evidence will be presented and evaluated.

At the completion of risk characterization, a Draft BERA Report will be prepared and submitted to EPA for review and approval in accordance with the schedule identified in the Final RI/FS Work Plan. An Amended Draft BERA Report will be submitted to EPA within 45 calendar days

of receipt of their comments related to the Draft BERA Report. The Final BERA will be submitted to EPA within 30 calendar days of receipt of their comments related to the Amended Draft BERA Report.

The following tasks will be completed as part of the risk characterization step.

5.6.7.1 Hazard Quotient Method

The potential risk posed to ecological receptors will be assessed by comparing estimated daily doses or media-specific concentrations with TRVs. This comparison, described as a HQ, will be made for each chemical and is expressed as shown below. Exposures to the same chemical through multiple exposure routes (e.g., ingestion of water, ingestion of prey) are assumed to be cumulative within the calculation of the HQ.

$HQ = C_{med}/TRV_{med}$

Where:

C_{med} = Concentration of a chemical in a medium (mg/kg or mg/L).
TRV_{med} = Toxicity reference value for the same chemical in the same medium (mg/kg or mg/L).

or:

$HQ = Dose_{total} / TRV_{ing}$

Where:

$Dose_{total}$ = Estimated daily dose of a chemical through all exposure routes and/or sources (i.e., soil, water, or food ingestion) (mg/kg-day).
TRV_{ing} = Toxicity reference value for the same chemical through the ingestion route (mg/kg-day).

If the calculated screening HQ exceeds unity (i.e., >1), then it simply indicates that the species of concern may be at risk to an adverse effect from that chemical through that exposure route. Because TRVs incorporate a number of extrapolation factors, if TRV is exceeded (i.e., the HQ exceeds unity), it does not necessarily indicate that an adverse effect will occur. Further evaluation (e.g., empirical field studies) may be needed for those chemicals with a screening HQ that exceeds one.

For chemicals acting via similar mechanisms, a Hazard Index (HI) will be determined to evaluate the potential accumulative risk posed by a set of chemicals with similar toxicological properties for that organism as follows:

$HI_{receptor} = HQ_{COPEC\ 1} + HQ_{COPEC\ 2}$

Where:

$HI_{receptor}$ = Hazard index for a measurement receptor.
$HQ_{COPEC\ 1}$ = Hazard quotient for that measurement receptor due to COPEC 1.
$HQ_{route\ 2}$ = Hazard quotient for that measurement receptor due to COPEC 2.

Because different chemicals affect different target organs through various mechanisms, HQs for different chemicals may not always be additive. Therefore, the risk characterization will consider summing multiple HI values (for different toxic mechanisms) in those case where the values are all less than but approach unity, and may exceed it if added. This provides the risk analysis with the ability of evaluating all chemicals across all sources/exposures and across different toxic mechanisms in order to fully consider the cumulative hazard to a particular receptor.

5.6.7.2 Site Investigation and Analysis of Exposure and Effects

The necessity for site-specific field studies will be evaluated by medium. There are a limited number of approaches currently available for conducting site-specific field investigations. These are: (1) bioaccumulation and field tissue residue studies; (2) population/community evaluations; and (3) toxicity testing (EPA, 1997). In determining the need and scope of field studies, the goals and impacts of testing will first be identified. The primary goal of field studies will be to reduce uncertainty in the ecological risk assessment modeling and to provide supporting information for any remedial measures, should they be required. Site-specific field studies may be necessary as part of a definitive ecological risk assessment (Steps 3 through 8 in Figure 16) if any one of the following criteria are met:

- A total HI exceeds one for any assessment endpoint.
- Exceedance of guidance values or criteria for media-based contamination (e.g., sediments).
- Identified receptor of concern (i.e., assessment endpoint) for which the lack of appropriate uptake algorithms precludes a complete exposure assessment.
- Insufficient toxicity data are available for assessment of potential impact.
- Associated uncertainty with modeling assumptions limits the effectiveness of the Hazard Quotient approach.

The need for site-specific field studies will be determined after review of the hazard quotient method results presented in the screening ecological risk assessment, and in consultation with the EPA. Any field studies, which may be selected should be relevant to the assessment endpoints that have been identified. Following is a brief discussion of the types of field studies that may be considered for the site.

5.6.7.2.1 Bioaccumulation and Field Tissue Residue Studies

Tissue residue studies can be performed to measure contaminant concentration in foods consumed by the target receptors associated with the selected assessment endpoints for the ecological risk assessment. This reduces the uncertainties associated with modeling potential exposures to selected target receptors. Types of residue studies that may be considered for future ecological risk assessment work at the Site include earthworm and fish tissue residue studies (EPA, 1997), including sediment invertebrate residue studies for invertebrates in the wetlands or Intracoastal Waterway/Redfish Bay.

5.6.7.2.2 Population/Community Evaluations

Population and community surveys evaluate the current status of an ecosystem, and can incorporate several measures of population or community structure or function. The most commonly used measures include number of species and abundance of organisms in an ecosystem. Some types of population/community evaluations that are performed at ecological sites include benthic macroinvertebrate surveys, fish community evaluations, and terrestrial plant community evaluations. Benthic macroinvertebrate surveys are the most common population/community evaluations conducted. Such studies are useful for evaluating the impacts of a contaminant already released into the environment. Although population/community studies can provide valuable information, there are often many confounding factors (e.g., natural population fluctuations in relation to population density and food availability) that need to be considered in interpreting results (EPA, 1997).

5.6.7.2.3 Toxicity Tests

Toxicity tests are used to directly evaluate the bioavailability and toxicity of site contaminants to selected test organisms (EPA, 1997). In toxicity tests, test organisms are exposed to a medium from site-specific groundwater, surface water, sediment, or soil in order to evaluate the effects of contamination on the survival, growth, reproduction, behavior, and/or other attributes of these organisms. Usually the studies are performed in a laboratory, but they may also be conducted on-site (*i.e.*, in situ tests). These tests help to determine whether contaminant concentrations in media at the site are high enough to cause adverse effects in organisms. Tests can either be acute or chronic. Acute tests last a short time, generally 4 days or less and mortality is the response measured. Chronic tests are used to study the effect of continuous, long-term exposure (about $1/10^{th}$ of an organisms lifespan or more), which generally evaluates sublethal effects (EPA, 1994b). Types of toxicity tests that may be considered for the site include soil toxicity to earthworms (e.g., survival, growth, reproduction), soil toxicity to plants (e.g., germination, root elongation, biomass), sediment toxicity to invertebrates (e.g., survival, growth), surface water toxicity to daphnia or fish (e.g., survival, growth, reproduction), and sediment or surface water toxicity to amphibians (e.g. frog embryo teratogenesis assay (FETAX)).

5.6.7.3 Uncertainty Analysis

As with the human health risk assessment, there are many uncertainties associated with estimating exposure and risks to ecological organisms. The uncertainty analysis will address the major assumptions that affect the degree of confidence in the estimate of risk. Variables such as exposure locations, strength of the exposure assumptions used in calculating doses, and the strength of the toxicological evidence supporting the toxicity values, will be evaluated in the uncertainty analysis. Quantitative measures of uncertainty will be conducted for potential cumulative risk to those inorganic chemicals that were screened out of the risk assessment using background comparisons.

5.6.8 Risk Management – Step 8

The responsibilities for the risk management at the site include the balancing of risk reductions associated with cleanup of contaminants with potential impacts of the remedial action themselves. The threshold for effects on the assessment endpoint as a range between contamination levels identified as posing no ecological risk and the lowest contamination levels identified as likely to produce adverse ecological effects will be identified in Step 7. The Remedial Project Manger will evaluate several factors in deciding whether or not to clean up to that range during Step 8. This risk management decision will be finalized by the EPA in the Record of Decision for the site.

5.7 Treatability Study

This Treatability Study (TS) Work Plan provides an overview of the methods to be used if a TS is conducted. As site information and remedial alternatives are developed for the site, the need for additional data to evaluate technology performance may be identified. This data need will determine whether or not a TS will be required for the site.

5.7.1 Objectives of the Treatability Study

The primary objectives of a TS include:

- Provide sufficient data to allow treatment alternatives to be fully developed and evaluated during the detailed analysis, and to support the remedial design of a selected alternative.
- Reduce cost and performance uncertainties for treatment alternatives to acceptable levels so that a remedy can be selected

5.7.2 Determination of Candidate Technologies and Need for Testing

During the site characterization and remedial alternative development phases of the RI/FS, potential candidate technologies for a TS program will be identified. These potential candidate technologies for TS will cover the range of technologies required for alternatives analysis.

Determination of the candidate technologies for TS will be begin with a literature survey that will be preformed to gather information for the following reasons:

- To determine whether the performance of the technologies under consideration have been sufficiently documented on similar wastes consider the scale and the number of times the technologies have been used.
- To gather information on relative costs, applicability, removal efficiencies, operation and maintenance requirements, and implementability on the candidate technologies.
- To determine testing requirements for bench or pilot studies, if required.

If the results of the literature survey indicate that the candidate technologies that address the site conditions have not been sufficiently demonstrated or cannot be adequately evaluated for the site on the basis of available information, treatability testing may be required.

In general, treatability testing is not necessary when:

- The data indicate that the technologies have been demonstrated sufficiently so the site-specific information collected during the site characterization is adequate to evaluate and cost those technologies.
- The technology is well developed and proven on similar applications.
- Substantial experience exists with a technology employing treatment of well-documented waste materials.
- Relatively low removal efficiencies are required.

A Draft Candidate Technologies Technical Memorandum (CTTM) will be prepared that includes a listing and justification of the candidate technologies for TS. The Draft CTTM will be submitted to EPA for review and approval according to the project schedule specified in the Final RI/FS Work Plan. An amended Draft CTTM will be prepared and submitted within 30 calendar days of receipt of the EPA's comments related to the Draft CTTM. A Final CTTM will be prepared and submitted within 14 calendar days of receipt of the EPA's comments related to the Amended Draft CTTM. The CTTM will include not only a listing of the candidate technologies for TS, but also the specific data requirements for the testing program that have been determined and refined during the characterization of the site and the development and screening of remedial alternatives.

Where it is determined by EPA that treatability testing is required, and unless it cannot be demonstrated to EPA's satisfaction that treatability testing is not needed, TSs will be performed, as outlined in the following section, including the preparation of a TS Work Plan.

5.7.3 Treatability Studies

If necessary, the treatability studies performed during the RI/FS is used to adequately evaluate a specific technology, to determine the suitability of the remedial technologies to site conditions and problems, and to adequately estimate cost and performance capabilities of a technology.

If the need for a treatability study is determined, additional literature review with supporting documents supporting the treatability study will be submitted as an attachment to the Alternative Development and Screening Technical Memorandum. The literature review should cover the performance, relative costs, applicability, removal efficiencies, operation and maintenance (O&M) requirements, and implementability of the remedial technologies. Additional review should be conducted to research parameters that impact treatability and compare these parameters to site characteristics. A TS may be needed for a remedial technology that has not been sufficiently demonstrated, or cannot be adequately evaluated, on the basis of available information.
If a treatability study is determined necessary, it will include the following steps:

- Preparation of a TS Work Plan for the bench or pilot studies.
- Performance of the field sampling, and/or bench testing, and/or pilot testing.
- Evaluation of data from the field studies, and/or bench testing and/or pilot testing.
- Preparation of a report documenting the results of the testing.

5.7.3.1 Bench Scale and Pilot Scale Studies

Once a decision has been made to perform TSs, the scale of treatability investigations of study (technology-specific bench scale studies and pilot scale studies) will be determined with concurrence from EPA. The decision to perform pilot testing will be made as early in the RI/FS process as possible to minimize potential delays of the FS because of the time required to design, fabricate, and install the required equipment. Whether bench scale or pilot scale testing will be performed will be determined with concurrence from EPA based upon:

- The level of development of the technology (bench scale testing is often appropriate for fully development technologies).
- The scale of the technology (bench scale testing may not be appropriate because of the physical size of the technology equipment).
- Schedule requirements.
- Cost versus benefit of type of generated data.

5.7.3.1.1 Bench Scale Testing

If a bench scale TS is conducted, it will most likely be conducted with small volumes of site waste being tested for the individual parameters of a treatment technology. The generated data will then be extrapolated to a full scale system appropriate for the site. If a bench scale study is performed, care will be taken in attempting to predict the performance of full-scale processes on the basis of the small scale tests.

Potential objectives of bench scale testing include:

- Effectiveness of the treatment alternative on the waste.
- Differences in performance between competing manufacturers.
- Differences in performance between alternative chemicals.
- Sizing requirements for pilot-scale studies.
- Screening of technologies to be pilot tested.
- Sizing of those treatment units that would sufficiently affect the cost of implementing the technology.
- Compatibility of materials with the waste.

Preplanning information that will be gathered prior to initiating bench scale studies includes:

- A waste sampling plan.
- Waste characterization.
- Treatment goals.
- Data requirement for estimating the cost of the technology being evaluated.
- Information related to the necessary equipment and services for the study.

5.7.3.1.2 Pilot Scale Testing

If pilot scale studies are performed, the pilot unit will be designed as small as possible to minimize cost, but large enough to generate the data required for scaling to full size unit. A larger volume of site waste will be required than for a bench scale study. The objective of a pilot scale test is to simulate the physical as well as chemical parameters of the full-scale process.

In addition to the preplanning information gathered for bench scale studies, the following will also be determined:

- Site information that would affect pilot-test requirements.
- Waste requirements for testing.

- Data requirement for technologies to be tested.

If the TS includes pilot scale testing, these activities will be initiated as early as possible to minimize potential delays in the FS.

5.7.3.2 Treatability Study Work Plan

A TS Work Plan will be prepared to delineate the objectives and scope of the TS. In general, the TS Work Plan will include the following:

- An explanation of the reasons for conducting the study and the objectives of the study, being attentive to consider chemical decontamination, materials handling, physical properties, and incidental waste stream issues which may be pertinent to the full scale implementation of the technology.
- An explanation of why the proposed scale of the study (bench or pilot) is appropriate to meet the objectives of the study.
- A detailed description of how the study will be conducted including a detailed description of each step of the study, equipment to be used, instrumentation and laboratory analysis methods, adjustments anticipated to be made during the study and all other information necessary to describe how the study will meet the study objectives. The study description will be made in the context of consideration of eventual full scale implementation and will address how scale differences between the study and full scale implementation will be considered and addressed in making recommendations about full scale implementability of the technology.
- A discussion of the material from the site to be subjected to the study, including how the selection of material is to address issues of site variability, how the technology being studied may be sensitive to site variances, how field sample selection is to be made to address variability and representativeness concerns, how samples are to be prepared (both during collection and as a part of the pretest sample handling), how sample preparation for the study may vary from material preparation during full scale implementation, and how differences between sample preparation for the study and material handling during full scale implementation may affect the validity of conclusions drawn as a result of the study.
- A discussion of the level of QA and QC that is appropriate in regard to data generated as a part of the study will be implemented.
- A discussion about how data from the study will be evaluated and presented to achieve the objectives of the study.
- An outline of the TS Report, which will be prepared to present the findings of the study.
- A schedule and cost estimate to conduct the study, including field sample collection and preparation of other appropriate required supporting plans such as FSP, HSP, and QAPP.

Because of the variations in bench scale and pilot scale testing programs, the format of the plans for each type of study that fulfills the requirements of the TS Work Plan listed above will vary.

5.7.3.2.1 Bench Scale Treatability Study Work Plan Outline

If the TS includes bench scale studies, the TS Work Plan will be prepared in the format of the following outline:

- Project Description and Site Background.
- Remediation Technology Description.
- Test Objectives.
- Specialized Equipment and Materials.
- Laboratory Test Procedures.
- Treatability Test Plan Matrix and Parameters to Measure.
- Analytical Methods.
- Data Management.
- Data Analysis and Interpretation.
- Health and Safety.
- Residuals Management.

5.7.3.2.2 Pilot Scale Treatability Study Work Plan Outline

If the TS includes pilot scale studies, the TS Work Plan will be prepared in the format of the following outline:

- Project Description and Site Background.
- Remediation Technology Description.
- Test Objectives.
- Pilot Plant Installation and Startup.
- Pilot Plant O&M Procedures.
- Parameters to be Tested.
- Sampling Plan.
- Analytical Methods.
- Data Management.
- Data Analysis and Interpretation.

- Health and Safety.
- Residuals Management.

5.7.4 TS Work Plan Deliverables

A Draft TS Work Plan will be prepared and submitted to EPA for review 60 days after the receipt of the EPA's notice that TS are required. In addition, a Draft SAP and a Draft HSP for the TS will also be prepared and submitted to EPA at the same time. An Amended Draft TS Work Plan, Amended Draft SAP and Amended Draft HSP will be submitted to EPA within 30 days of receipt of the EPA's comments on the draft documents. A Final TS Work Plan, SAP and HSP will be submitted to EPA within 14 days of receipt of the EPA's comments on the amended draft documents.

5.7.5 Treatability Study Report

Upon completion of the TS, a TS Report shall be submitted to EPA. This report will evaluate the technology's effectiveness and implementability in relation to the remedial goals established for the site. In addition, actual results will be compared with predicted results to justify the effectiveness and implementability discussions detailing the results. The TS Report will include (as applicable):

- A description of the remedial technology being studied;
- A description of the test objectives;
- A detailed description of each step of the study from sample collection through data evaluation, highlighting any deviations from the TS Plan and discussing how those deviations may have affected meeting the test objectives or making valid conclusions about the suitability or implementability of the technology for the project;
- Data management and analysis;
- Health and safety.
- Residual waste management
- A detailed presentation of conclusions (including how each test objective was or was not achieved) and recommendations relating to the suitability of the technology to meet the full-scale objectives of the project. The discussion will address factors, which may affect the successful full-scale implementation of the technology, and how those factors can be mitigated during full-scale implementation. The report will include recommendations about how to procure, specify, and compensate the future contractor for implementation of the full-scale technology to maximize the opportunity for successful completion of the project, and
- An executive summary describing the objectives and major conclusions and recommendations of the study.

The Draft TS Report will be prepared and submitted according to the schedule identified in the Final TS Work Plan. An Amended Draft TS Report will be submitted within 45 calendar days of receipt of the EPA's comments related to the Draft TS Report. A Final TS Report will be submitted within 30 calendar days of receipt of the EPA's comments on the Amended Draft TS Report.

5.8 Feasibility Workplan

This FS Work Plan (Plan) provides an overview of the methods that will be used in conducting the FS for the site. The Plan will present the objectives and methodology of the FS and a schedule for completion of the FS.

5.8.1 Feasibility Study Objectives

The objectives of the FS are to develop and evaluate remedial alternatives in order to allow selection of appropriate remedial actions for the site. The FS will be conducted to meet the objectives set forth in the NCP [NCP 40 CFR 300.430 30 (e)] and in accordance with the EPA guidance document, Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final, October 1988 (RI/FS Guidance Document), and/or other applicable guidance documents.

5.8.1.1 Phases of the Feasibility Study

In accordance with guidance, the FS process occurs in three phases: the development of alternatives, the screening of alternatives, and the detailed analysis of alternatives. In practice, the point at which the development phase ends and the screening phase begins is generally not distinct. Therefore, this Plan will combine the first two phases (development and screening of alternatives) to reflect the interrelatedness of these efforts.

In the alternative development and screening phase, an appropriate range of remedial options will be developed. These alternatives will be developed concurrently with the RI site characterization in an iterative manner. The tasks that will be completed during the alternative development and screening phase for the site are identified in Section 5.8.2.

The detailed analysis of alternatives will consist of analysis and presentation of the relevant information that will be used to select the remedy(s) for the site. The results of the analysis will be prepared so that an objective comparison can be made between alternatives, and the key advantages and disadvantages of the alternatives are identified. The tasks that will be completed during the detailed analysis of alternatives for the site are provided in Section 5.8.3.

At the conclusion of the FS process, sufficient information will be available to adequately compare the alternatives so that the appropriate remedy for the site can be selected.

5.8.2 Development and Screening of Alternatives

Alternatives for remediation will be developed by assembling appropriate combinations of technologies, and the media to which they will be applied, into alternatives that address the site contamination. Appropriate remedial options will include those that ensure the protection of human health and the environment. This alternative development consists of seven general steps:

- Develop remedial action objectives that specify contaminants and media of interest, exposure pathways, and remediation goals.
- Develop general response actions for each medium of interest that define the activity that may be taken to achieve the remedial action objectives.
- Identify the volumes or areas of media that will be treated by the general response actions, based on the remedial action objectives and the chemical and physical site characterization.
- Identify and screen the technologies applicable to each general response action to identify those that can and cannot be implemented technically at the site.
- Identify, evaluate, and select a representative process for each technology type that has been retained for consideration during the previous step.
- Assemble the selected representative technologies into alternatives representing a range of remedial actions.
- Screen the representative alternatives.

An Alternative Development and Screening Technical Memorandum (ADSM) will be prepared that will summarize the results of these tasks. This memorandum will be submitted for approval in accordance with the schedule. The tasks that will be implemented for each of these steps are detailed in the following sections.

5.8.2.1 Task 1 – Develop Remedial Action Objectives

Remedial action objectives that consist of medium-specific or operable unit-specific goals for protecting human health and the environment will be developed. The site-specific remedial action objectives will identify:

- Contaminants of concern for each affected medium (or unit).
- Potential exposure pathways and receptors.
- Preliminary remediation goals for the site that establish acceptable contaminant levels, or range of levels, for each exposure route and that are protective of public health and the environment.

The remedial action objectives will define both a contaminant level and an exposure route because protectiveness may be achieved by reducing exposure alone, or in combination with reducing contaminant levels.

Preliminary development of the remediation goals will be based on frequently used medium-specific exposure standards, including Applicable or Relevant and Appropriate Requirements (ARARs). However, the final remediation goals, specifically the acceptable exposure levels, will be determined based upon the results of the human health and ecological baseline risk assessments for the site and on the evaluation of the expected exposure and associated risks for each remedial alternative. Contaminant levels in each medium will be compared with these acceptable levels to ensure the following:

- The remediation goals for all carcinogens of concern will be within the acceptable risk range of 1.0×10^{-4} to 1.0×10^{-6}, or the probability of one in 10,000 to one in 1,000,000 individuals developing cancer as a result of site-related contaminants, respectively.
- The remediation goals for all non-carcinogens of concern are sufficiently protective.
- The human health and environmental effects are adequately addressed.
- The exposure analysis conducted as part of the risk assessments adequately address each significant pathway of exposure identified in the baseline risk assessments.

5.8.2.2 Task 2 – Develop General Response Actions

Medium specific, general response actions will be developed that describe actions that will satisfy the remedial action objectives. Potential media to be addressed include surface and subsurface soils, sediment, surface water, and groundwater. The contents of the tanks and piping leading from the North Site to the historical and current docking areas will be addressed by the ongoing Removal action and the planned Remedial Action.

Potential general response actions for the site may include treatment, containment, excavation, extraction, disposal, institutional controls, or a combination of these options. Combinations of general response actions may be defined to address the various media, in particular when actions are interdependent (i.e., when disposal methods primarily depend on whether the medium has been previously treated).

The general response actions will be initially defined during the initial RI phase and will be refined throughout the remainder of the RI/FS process as understanding of site conditions and action-specific remedial objectives are refined.

5.8.2.3 Task 3 – Identify Volumes or Areas of Media

During the development of alternatives, initial estimates will be made of areas or volumes of each media of interest at the site to which the general response actions could apply. These estimates will be refined to take into account potential interactions of various media indicated by

the nature of the general response actions. Careful judgment will be utilized when defining the areas or volumes of media and acceptable exposure levels and potential exposure routes, site conditions, and the nature and extent of contamination.

5.8.2.4 Task 4 – Identify and Screen Remedial Technologies and Process Options

During this task, potentially applicable technology types and process options will be identified for each general response action. Only remediation technologies that are applicable to the contaminants present, their physical matrix, and other site characteristics will be evaluated. Technology types refer to general categories of technologies, such as chemical treatment, immobilization, capping, or extraction. Technology processes refer to specific processes within each technology type, such as chemical treatment process technologies could include precipitation, ion exchange and oxidation/reduction. The number of technology types and process options will then be reduced by evaluating the options, with respect to technical implementability. Technology types and process options will be identified based on experience, literature sources, and standard engineering practices as applicable to site conditions.

During screening, process options and entire technology types will be retained, or eliminated from further consideration, on the basis of technical implementability. This screening will use readily available information from the RI site characterization. Specifically, information on contaminant types, concentrations, and on-site characteristics will be utilized to screen out technologies and process options that cannot be effectively implemented.

The remedial technologies and process options screening process will be documented, and this documentation will be provided in the RI/FS report.

5.8.2.5 Task 5 – Evaluate Process Options

Representative processes for each technology type will be selected to simplify the subsequent development and evaluation of alternatives, without limiting the flexibility during remedial design. During this process evaluation step, technology processes still under consideration will be evaluated in greater detail, so that the most appropriate process for each technology type can be selected. The selected processes will provide a basis for developing performance specifications during the preliminary design even though the specific processes actually implemented during the remedial actions at the site may not be selected until the remedial design phase. An attempt will be made to select one representative process for each technology type. However, more than one process may be selected if they all are sufficiently different in their performance that one would not adequately represent the other.

Process options will be evaluated using the following criteria:

- Effectiveness.
- Implementability.
- Cost.

In addition, the process evaluation will generally apply these criteria only to the technologies and the general response actions they are intended to satisfy and not to the site as a whole.

Application of these criteria is detailed in the following sections.

5.8.2.5.1 Effectiveness Evaluation

The process evaluation will generally emphasize the effectiveness criteria over implementability and cost. The identified technology processes will be evaluated on their effectiveness related to other processes within the same technology type. The effectiveness evaluation will focus on:

- The potential effectiveness of process options in handling the estimated areas or volumes of media and in meeting the remediation goals identified in the remedial action objectives.
- The potential impacts to human health and the environment during the construction and implementation phase.
- How proven and reliable the process is with respect to the contaminants and site conditions.

Site information, such as the contaminant type and concentration, the area or volume of contaminated media, and, when appropriate, rates of media removal, collection, or treatment will be reviewed as part of the process effectiveness evaluation. If necessary to evaluate the process effectiveness for specific media, preliminary analyses will be conducted and/or additional site data will be collected. A limited conceptual design of the process may be developed, and/or the potential environmental transport mechanisms associated with the process may be modeled. However, these activities are typically completed during later phases of the FS, when alternatives are evaluated on a site-wide basis.

5.8.2.5.2 Implementability Evaluation

The technical and administrative feasibility of implementing each technical process will be evaluated. Those options that are clearly ineffective, or unworkable at the site, will be eliminated during the technology process screening.

5.8.2.5.3 Cost Evaluation

Relative capital and O&M costs will be developed to screen the process options. This costs analysis will be made on the basis of engineering judgment, and each process will be evaluated as to whether costs are high, medium, or low, relative to the process options in the technology type.

5.8.2.6 Task 6 – Assemble Potential Remedial Alternatives

The general response actions and the process options chosen to represent the various technology types for each medium or unit will be combined to form alternatives for the site as a whole. Together, the alternatives will represent a range of treatment and containment combinations that will address the contamination at the site. In addition, the no-action alternative will be considered for each medium and/or unit.

5.8.2.7 Task 7 – Alternatives Screening Process

The screening process of all assembled potential remedial alternatives will be completed in three steps:

- Alternatives definition.
- Screening evaluation.
- Alternative screening.

The following sections provide details for each of these three alternative screening steps.

5.8.2.7.1 Alternatives Definition

Each alternative will be more completely defined so that the alternatives can be evaluated and compared before their screening. First, each alternative will be evaluated with regards to the specific remedial objectives to ensure that they are protective of human health and the environment for each potential pathway of concern at the site, or for those areas of the site being addressed as part of an operable unit. If more than one pathway is present, the overall risk level to receptors will be evaluated. If an alternative is found to be not fully protective, a reduction in exposure levels for one or more media will be made to attain an acceptable risk level by refining the remedial alternative. In refining alternatives, it will be noted that protectiveness will be achieved by reducing exposures to acceptable levels, but achieving these reductions in exposure may not always be possible by actually cleaning up a specific medium to these same levels. Potential actions in this situation may include refinement of the technological process specified by the remedial alternative or elimination of the alternative from consideration.

Secondly, alternatives will be more completely defined to provide sufficient quantitative information to allow differentiation among alternatives with respect to effectiveness, implementability and cost. This will include such aspects of the alternatives as the extent and volume of contaminated material and the size of the major technology and process options. Refinement of volumes or areas of contaminated media will be reviewed to ensure that an ongoing release from the site has not significantly affected contaminant levels in other media since the point in time when the alternatives were initially developed.

In addition, the following information will be developed for the various technology processes used in each alternative:

- Size and configuration of on-site treatment systems or containment structures.
- Time frame in which treatment, containment, or removal goals can be achieved.
- Rates or flow of treatment.
- Spatial requirements for constructing treatment or containment technologies, or for staging construction materials or excavated soil or waste.
- Distances for disposal technologies.
- Required permits for off-site actions and imposed limitations.

5.8.2.7.2 Screening Evaluation

Once the alternatives are completely defined, they will be evaluated against the short and long term aspects of the effectiveness, implementability and cost. The goal of this step is to reduce the number of alternatives that will undergo the more thorough and extensive analysis. In addition, while the evaluation at this time will be sufficiently detailed to distinguish among alternatives, it will be more general than the final evaluation of the detailed alternatives.
If innovative technologies are included in the remedial alternatives, the evaluation will be based on "reasonable belief" from data from full-scale applications under similar circumstances, and/or from bench-scale or pilot-scale treatability testing that supports expectations that the new technology will offer significant advantages. If TS are implemented for the site, these activities will be performed in accordance with the TS Work Plan.

The short- and long-term aspects of the following criteria will be used to develop and screen remedial alternatives:

- ***Effectiveness.*** Alternatives that do not effectively provide adequate protection of human health and the environment will be eliminated from further consideration. Each alternative will be evaluated as to its effectiveness in providing protection and the reductions in toxicity, mobility, or volume that it will achieve. Short-term effectiveness refers to the construction and implementation period. Long-term effectiveness refers to the period after the remedial action is complete.
- ***Implementability.*** Alternatives that are technically or administratively infeasible or that would require equipment, specialists, or facilities that are not available within a reasonable period of time, will be eliminated from further consideration. Technical feasibility includes the ability to construct, reliable operate and meet technology-specific regulation for process options until a remedial option is complete. Technical feasibility also includes O&M, replacement and monitoring of technical components of an alternative into the future after the remedial action is complete. Administrative feasibility refers to the ability to obtain approvals from other offices and agencies, the availability of

treatment, storage, and disposal services and capacity, and the requirements for, and availability of, specific equipment and technical specialists.

- ***Cost.*** Alternatives providing effectiveness and implementability similar to that of another alternative by employing a similar method of treatment or engineering control, but at greater cost, will be eliminated. Comparative estimates of the costs for all alternatives will be made with relative accuracy so that costs decision among alternatives will be sustained as the accuracy of cost estimates improves beyond the screening process. Cost estimates for screening alternatives will be based on cost curves, generic unit costs, vendor information, conventional cost-estimating guides, and prior similar estimates as modified by site-specific information. Prior estimates, site-cost experience, and good engineering judgments will be utilized to identify those unique items in each alternative that will control the comparative estimates. Both capital and O&M costs will be considered and present worth analysis of these costs will be applied.

Alternatives with the most favorable composite evaluation of all factors will be retained for further consideration during the detailed analysis. The selected alternatives will preserve the range of treatment and containment technologies initially developed.

After the evaluation has been completed, a Draft ADSM will be submitted to the EPA for review as specified in the Final RI/FS WP. An Amended Draft ADSM will be submitted to the EPA within 30 calendar days of the receipt of comments on the Draft ADSM. A Final ADSM will be submitted to the EPA within 14 calendar days of the receipt of comments on the Amended Draft ADSM.

5.8.2.8 Post Screening Activities

The results of the screening process may identify additional investigations needed to adequately evaluate the alternatives in the detailed analysis. Therefore, to ensure a smooth transition from the screening of alternatives to the detailed analysis, the action-specific ARARs will be identified and verified. In addition, treatability testing (if not done previously) and additional site characterization may be initiated.

5.8.3 Detailed Analysis of Remedial Alternatives

The detailed analysis of alternatives will consist of the analysis and presentation of the relevant information so that the site remedy can be selected. During this analysis, each alternative will be assessed against the nine evaluation criteria, and the results of this assessment will be arrayed to compare the relative performance of each alternative against those criteria. This step will identify the advantages or disadvantages among them. As a result of this analysis, sufficient information will be presented to adequately compare the alternatives, to identify and select an appropriate remedial action(s), and to demonstrate satisfaction that the remedy selection process meets the regulatory requirements.

The detailed analysis will consist of the following components:

- Further definition of each alternative, if necessary, with respect to the volumes or areas of contaminated media to be addressed, the technologies to be used, and any performance requirements associated with those technologies.
- An assessment and a summary profile of each alternative against the evaluation criteria.
- A comparative analysis among the alternatives to assess the relative performance of each alternative with respect to each evaluation criterion.
- Alternatives Definition

Each alternative will be reviewed to determine if an additional definition is required to apply the evaluation criteria consistently and to develop order-of magnitude cost estimates. Information developed to define alternatives at this stage in the FS process will consist of preliminary design calculations, process flow diagrams, sizing of key process components, preliminary site layouts, and a discussion of limitations, assumptions, and uncertainties concerning each alternative.

5.8.3.1 Evaluation Criteria

Each of the alternatives will be evaluated relative to nine criteria to develop the rationale for a remedy selection. The nine evaluation criteria include:

- Overall protection of human health and the environment.
- Compliance with ARARs.
- Long-term effectiveness and permanence.
- Reduction of toxicity, mobility, or volume.
- Short-term effectiveness.
- Implementability.
- Cost.
- State acceptance.
- Community acceptance.

The first two criteria (overall protection of human health and the environment and compliance with ARARs) will be considered threshold criteria that must be met by any selected alternative. The next five criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability; cost) represent the primary criteria upon which the analysis will be based. The final two criteria (state and community acceptance) will be evaluated following comment on the RI/FS report and proposed plan and will be addressed by EPA when a final decision is being made.

A Nine Criteria Analysis Memorandum (NCAM) will be prepared that will summarize the results of this evaluation. This memorandum will be submitted for approval in accordance with the schedule identified in the Order.

5.8.3.1.1 Overall Protection of Human Health and the Environment

A final check will be made to ensure that each alternative provides adequate protection of human health and the environment. The assessment against this criterion will include a description of how the alternative, as a whole, achieves and maintains protection, and how the site risks posed through each pathway will be eliminated, reduced, or controlled through treatment, engineering or institutional controls.

5.8.3.1.2 Compliance with ARARs

This evaluation criterion will be used to determine whether each alternative will meet all of the ARARs that will be identified in previous stages of the RI/FS process. The detailed analysis relative to this criterion will summarize the requirements applicable or relevant and appropriate to an alternative, and describe how the alternative meets these requirements.

Compliance with chemical-specific, location-specific, and action-specific ARARs will be determined for each alternative. A summary of these ARARs and whether they will be attained by a specific alternative will be presented.

5.8.3.1.3 Long-term Effectiveness and Permanence

The assessment of alternatives against this criterion will address long-term effectiveness and permanence in maintaining protection of human health and the environment after remedial alternatives have been completed and response objectives have been met, as well as the degree of certainty that each alternative will prove successful. Specifically, the following components of this criterion will be addressed for each alternative:

- **Magnitude of residual risk remaining from untreated waste or treatment residuals at the conclusion of remedial activities.** The characteristics of the residual risk will be considered given the residual volume of contaminated media and the toxicity, mobility, and propensity to bioaccumulate of each residual contaminant. The magnitude of residual risk will be assessed by numerical standards such as cancer risk levels or noncancer hazard indices.
- **Adequacy and reliability of controls that will be used to manage treatment residuals, or untreated wastes, remaining at the Site.** This factor addresses:
- The uncertainties associated with the remedial alternatives for providing long-term protection from residuals;
- The assessment of the potential need to replace technical components of each remedial alternative (e.g., surface caps, slurry walls, or treatment systems); and

- The potential exposure pathways and risks posed should the remedial alternative need replacement.

5.8.3.1.4 Reduction of Toxicity, Mobility or Volume

The assessment of alternatives against this criterion will evaluate the anticipated performance of the specific treatment technologies for each alternative with respect to reduction of toxicity, mobility or volume of the hazardous substances. This evaluation will focus on the following specific factors for each alternative:

- The treatment process that will be used and the materials they will treat.
- The amount of hazardous materials that will be destroyed or treated.
- The percentage measure of expected reduction in toxicity, mobility or volume.
- The degree to which the treatment will be irreversible.
- The type and quantity of treatment residual that will remain following treatment.
- Whether the alternative would satisfy the statutory preference for treatment as a principal element.

When evaluating against this criterion, an assessment will be made as to whether treatment is used to reduce principal threats, including the extent to which toxicity, mobility or volume are reduced either alone or in combination.

5.8.3.1.5 Short-Term Effectiveness

The assessment of alternatives against this criterion will include evaluation of the effects of each alternative during the construction and implementation phase until remedial response objectives are met. The following factors will be evaluated:

- Protection of the community during remedial actions, including any risk that may result from implementation of the proposed remedial action.
- Protection of workers during remedial actions, including threats than may be posed to workers and the effectiveness and reliability of protective measures that would be taken.
- Environmental impacts that may result from the construction and implementation of an alternative, including the reliability of the available mitigation measures in preventing or reducing the potential impacts.
- Time until remedial response objectives are achieved.
- Implementability

Evaluation with respect to this criterion will address the technical and administrative feasibility of implementing an alternative and the availability of various services and material required during its implementation. The following factors will be evaluated:

- Technical feasibility, including construction and operation, reliability of technology, ease of undertaking additional remedial action (i.e., in a situation where an interim action is or will be implemented), and effectiveness monitoring considerations.
- Administrative feasibility including the activities needed to coordinate with all offices and agencies.
- Availability of services and materials including off-site treatment, storage and disposal services; necessary equipment, specialist, and provisions; competitive services and materials; and prospective technologies.

5.8.3.1.6 Cost

This criterion will be used to evaluate the capital and O&M costs of each alternative. All indirect and direct capital costs and O&M costs associated with each alternative will be developed, including a schedule defining when they will be incurred. The level of accuracy of all costs will be estimated, and a present worth analysis will be used to evaluate expenditures that may occur over different time periods. Additional costs may be evaluated through a sensitivity analysis if there is sufficient uncertainty concerning specific assumptions. The results of the sensitivity analysis will be utilized to identify worst-case scenarios and to revise estimates of contingency or reserve funds.

5.8.3.1.7 State Acceptance

The assessment of alternatives with respect to this criterion evaluates the technical and administrative issues and concerns the state or other support agency may have regarding each of the alternatives. This evaluation will be provided by the EPA.

5.8.3.1.8 Community Acceptance

The assessment of alternatives with respect to this criterion evaluates the issues and concerns the public may have regarding each of the alternatives. This evaluation will be provided by the EPA.

5.8.4 Presentation of Individual and Comparative Analysis

A Remedial Alternatives Comparative Analysis (RACA) Report summarizing the results of the analysis of each remedial alternative will be prepared. The analysis of alternatives with respect to the specified criteria will be presented as a narrative discussion accompanied by a summary table. This information will be provided for use in the comparison of alternatives and in support of a subsequent analysis of the alternatives during the remedy selection process. The narrative

for each alternative will provide a technical description of each alternative and a discussion of the individual criteria assessment.

This memorandum will also include the comparative analysis of all options. The comparative analysis will include the evaluation of the relative performance of each alternative in relation to each specific evaluation criterion. This evaluation will identify the advantages and disadvantages of each alternative relative to one another. The comparative analysis will include a narrative discussion describing the strengths and weaknesses of each alternative relative to one another with respect to each criterion. The comparison of the differences will be measured either qualitatively or quantitatively, and will identify the substantive differences.

5.8.5 Schedule

As specified in the Order for the Site, the following memoranda and reports will be submitted in accordance with the indicated schedule.

5.8.5.1 Detailed Analysis of Alternatives for Remedial Action Reporting

The Order for the Site specifies reporting requirements describing the detailed analyses of alternatives including the NCAM, the RACA Report, and the Presentation to EPA. In addition, the results of the detailed analyses of alternatives will be detailed in a Draft FS Report that will be submitted in accordance with the schedule identified in the Final RI/FS Work Plan.

The Draft NCAM will be submitted to EPA for review and approval according to the project schedule specified in the Final RI/FS Work Plan. The Amended Draft NACM will be prepared and submitted within 30 calendar days of receipt of EPA's comments to the Draft NCAM. The Final NCAM will be then be prepared and submitted within 14 days of receipt of EPA's comment to the Amended Draft NCAM.

The initial RACA Report will be submitted to EPA for review and approval according to the project schedule specified in the Final RI/FS Work Plan. The Amended Draft RACA Report will be prepared and submitted within 30 calendar days of receipt of EPA's comments to the initial RACA Report. The Final RACA Report will be then be prepared and submitted within 14 days of receipt of EPA's comment to the Amended Draft RACA Report.

A presentation will be prepared for EPA which details and discusses the findings of the RI, the remedial action objectives, the alternatives evaluated in the FS, and the results of the comparative analysis. This presentation will be made in accordance with the schedule identified in the Final RI/FS Work Plan.

The Draft FS Report will be prepared and submitted to EPA for review and comments in accordance with the schedule identified in the Final RI/FS Work Plan. The Amended Draft FS Report will be prepared and submitted within 30 calendar days of receipt of the EPA's comments to the Draft FS Report.

5.8.5.2 Final Feasibility Study Report

The Final FS Report will provide the basis for the Proposed Plan developed by the EPA and shall document the development and analysis of remedial alternatives. The Final FS Report will be prepared and submitted to EPA within 14 calendar days of receipt EPA's comments on the Amended Draft FS Report.

6.0 SCHEDULE

The project schedule will be amended on a monthly basis and changes to the schedule will be addressed in the Monthly Progress Report. Changes to the due dates for the RI/FS deliverables (specified in the RI/FS SOW) will be approved by the EPA.

A copy of the anticipated schedule is included in Appendix J.

7.0 PROJECT MANAGEMENT

The Project Team, which is depicted in Figure 18, includes Rafael Casanova of the EPA as the Remedial Project Manager (RPM) and Stephen Halasz as the Project Coordinator (PC). Richard Bergner is the NORCO representative and the PC will be responsible for receiving NORCO concurrence on all actions.

The RPM has the authority to halt, conduct or direct Work required by the Agreed Order and to take necessary response actions. Absence of the RPM will not be a cause for work stoppage or delay.

Communication between NORCO and the EPA will predominantly be in writing and directed to the PC on behalf of NORCO and the RPM on behalf of the EPA. Communications include but are not limited to all documents, notices, reports, approvals, disapprovals and other correspondence addressed in the Agreed Order.

In matter dealing with dispute resolution the RPM and the PC will make all attempts to resolve the issue informally. If a resolution cannot be reached the procedures described in the Agreed Order will be implemented.

The NORCO Project Team, which is headed by the PC, consists of staff members from Kleinfelder, Severn Trent Laboratories and additional subcontractors. All activities will be performed in compliance with the HSP and the approved RI/FS Work Plan. Prior to the submission of this work plan the qualifications of the project team were furnished to the RPM.

Specific responsibilities concerning sampling, sample shipment and laboratory analysis are addressed in the QAPP.

Any changes to the Project Team will be reported to the RPM at least seven days before the change.

8.0 REPORTING

On a monthly basis, by the 10th of each month a Monthly Progress Report will be submitted to the EPA. The format for the report has been approved by the EPA and each report will be posted to the document repository.

8.1 RI Report

The RI Report will be prepared to document the results of the RI at the site, to provide the necessary data for use in preparing the site BHHRA, the BERA and as documentation of the data collection and analysis in support of the FS.

The RI Report includes the following information:

- Summaries of the implemented field investigation activities;
- Characterization of site conditions based on the results of the field investigations;
- Groundwater classification;
- Appropriate site-specific discussions related to the fate and transport of the site constituents; and
- Results of both the BHHRA and the BERA.

The RI Report will be prepared following EPA's guidance "Interim Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA". The report will focus on the site constituents and media of concern as well as other site-specific conditions. Those subjects identified in EPA's suggested report format and others as appropriate that pertain to the site and the results of the RI will be included in the report.

A Draft RI Report will be prepared and submitted to the EPA for review and approval according to the schedule specified in the Final RI/FS WP. The amended Draft RI Report will be submitted to the EPA within 45 calendar days of receipt of the EPA's comments related to the Draft RI Report. The Final RI Report will be submitted within 30 days of receipt of the EPA's comments related to the Amended draft RI Report.

The following report format will be used:

Executive Summary

1. Introduction
1.1 Purpose of Report

1.2 Site Background
    1.2.1 Site Description
    1.2.2 Site History
    1.2.3 Previous Investigations
1.3 Report Organization

2. Study Area Investigation

2.1 Description of Remedial Investigation Field Activities
    2.1.1 Surface Features
    2.1.2 Contaminant Source Investigations
    2.1.3 Meteorological Investigations
    2.1.4 Surface Water and Sediment Investigations
    2.1.5 Geological Investigations
    2.1.6 Soil and Vadose Zone Investigations
    2.1.7 Groundwater Investigations
    2.1.8 Human Population Surveys
    2.1.9 Ecological Investigations
2.2 If technical memoranda documenting field activities were prepared, they may be included in an appendix and summarized in this report chapter.

3. Physical Characteristics of the Study Area

3.1 Includes results of field activities to determine physical characteristics. These may include some, but not necessarily all, of the following:
    3.1.1 Surface Features
    3.1.2 Meteorology
    3.1.3 Surface-Water Hydrology
    3.1.4 Geology
    3.1.5 Soils
    3.1.6 Hydrogeology
    3.1.7 Demography and Land Use
    3.1.8 Ecology

4. Nature and Extent of Contamination

4.1 Presents the results of site characterization, both natural chemical components and contaminants in some, but not necessarily all, of the following media:
    4.1.1 Sources (soils, AST contents, surface water, sediments etc.)
    4.1.2 Soils and Vadose Zone
    4.1.3 Groundwater
    4.1.4 Surface Water and Sediments
    4.1.5 Air

5. Contaminant Fate and Transport

5.1 Potential Routes of Migration (i.e., air, surface water, ground water, etc.)
5.2 Contaminant Persistence

5.2.1 If they are applicable (i.e., for organic contaminants), describe estimated persistence in the study area environment and physical, chemical, and/or biological factors of importance for the media of interest

5.3 Contaminant Migration

5.3.1 Discuss factors affecting contaminant migration for the media of importance (e.g., sorption onto soils, solubility in water, movement of ground water, etc.)

5.3.2 Discuss modeling methods and results, if applicable.

6. Baseline Risk Assessment

6.1 Human Health Evaluation

6.1.1 Exposure Assessment

6.1.2 Toxicity Assessment

6.1.3 Risk Characterization

6.2 Environmental Evaluation

7. Summary and Conclusions

7.1 Summary

7.1.1 Nature and Extent of Contamination

7.1.2 Fate and Transport

7.1.3 Risk Assessment

7.2 Conclusions

7.2.1 Data Limitations and Recommendations for Future Work

7.2.2 Recommended Remedial Action Objectives